

Wageningen UR Livestock Research

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Natural handicaps in Dutch agricultural areas.
Assessment of less favoured areas based on
economic criteria

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Abstract

The reports describes the fine tuning of the
selection of Less Favoured Areas in the
Netherlands. The fine tuning is based on the
effects of biophysical handicaps on the gross
margin of arable and dairy farms. A selection of
Less Favoured Areas in the Netherlands is
proposed.

Keywords

Less Favoured Areas, biophysical handicaps,
gross margin, economic models

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Title

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Preface

This report is a cooperation between: Wageningen UR Livestock Research, Applied Plant Research and Alterra. The work of this report builds on the results as presented in a report by Smit and Brouwer (2009). For a full understanding of this report and the final results, both reports should be used.

Part of the information in this report is based on the network of researchers and managers of experimental stations in the Netherlands. They are not in the list of authors, we are grateful for their help.

Smit, A., Brouwer, F., 2009. Natural handicaps in Dutch agricultural areas. Assessment of less favoured areas based on biophysical criteria. Wageningen UR, Alterra, Report 1970. Wageningen, the Netherlands, p. 52.

Samenvatting

Smit en Brouwer (2009) hebben gebieden met een landbouwkundige handicap geselecteerd aan de hand van biofysische criteria. De relevante biofysische criteria waren gerelateerd aan bodemeigenschappen: drainage, textuur, aanwezigheid van stenen en chemische eigenschappen. Textuur en aanwezigheid van stenen zijn onderverdeeld in verschillende klassen: grof materiaal, grof en middelgrof zand, zware klei, veengronden, zwel en krimpverschijnselen en het opkomen van stenen uit de ondergrond. Verzilting is de enige chemische eigenschap die relevant is voor Nederland. Naast een selectie van gebieden op grond van biofysische eigenschappen, moet ook een verfijnde selectie worden uitgevoerd. Deze verfijnde selectie is gebaseerd op de verschillen in saldo per hectare tussen gebieden met en zonder de landbouwkundige gevolgen van de biofysische eigenschappen.

De belangrijkste landbouwkundige gevolgen voor de verschillende categorieën waren de gevoeligheid voor winderosie bij grof en middelgrof zand; de beperkingen van de bewerkbaarheid van de grond en de beperkingen in het bouwplan op de zware kleigronden en lagere netto productie en de onmogelijkheid om maïs te verbouwen op veengronden. De landbouwkundige gevolgen van zwel en krimp en van zilte omstandigheden waren beperkt. Bedrijfseconomische berekeningen zijn uitgevoerd voor akkerbouwbedrijven op grof en middelgrof zand en op zware klei en voor melkveebedrijven op veengrond. In alle gevallen was het saldo per hectare lager voor de handicapgebieden, variërend van € 76,- tot € 192,- per hectare per jaar.

De uiteindelijke lijst van gemeenten (LAU-2 gebieden) waar tenminste 66% van de landbouwgrond tot de handicapgebieden behoort is aangepast aan de hand van de verfijnde selectie. De uiteindelijke lijst na de verfijnde selectie is de helft ten opzichte van de selectie op basis van biofysische eigenschappen.

Summary

Less Favoured Areas have been selected by applying biophysical criteria by Smit and Brouwer (2009). The relevant biophysical criteria were soil related: drainage, texture and stoniness and chemical properties. Texture and stoniness was subdivided in several classes: coarse material, coarse and medium sand, heavy clay, organic soils, vertic properties and rock outcrop. Salinity is the only chemical property that is relevant for Dutch conditions. Additional to the selection on the basis of the biophysical criteria, a fine tuning is required. The fine tuning is based on the comparison of the gross margin per hectare for farming conditions with and without the specific agronomic consequences of the biophysical soil properties.

The main agronomic consequences for the different categories were the susceptibility for wind erosion for coarse and medium sand; the limited workability and the limitations in crop rotations on heavy clay soils and the lower productivity and inability to grow maize on peat soils. The agronomic consequences of soils with vertic properties and of saline soils were assessed to be limited.

Calculations have been done for arable farms on coarse and medium sand and on heavy clay soils and for dairy farms on peat soils. In all situations a lower gross margin has been calculated, ranging from € 76 to 192 per hectare per year.

The final list of LAU-2 units (municipalities) where at least 66 % of the agricultural land belongs to the Less Favoured Areas is adjusted on the basis of the fine tuning. Fine tuning reduced the number of municipalities classified as the Less Favoured Areas by half.

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1 Introduction

In order to assess less favoured areas (LFA) where production is limited by biophysical handicaps, the European Commission proposed a set of biophysical criteria (Van Orshoven et al., 2008). Smit and Brouwer (2009) elaborated this set of biophysical criteria for the Dutch situation. A summary of the identified handicaps is shown in Table 1. This table shows that a limited number of biophysical handicaps is relevant for the Netherlands. The handicaps “climate”, “soil & climate”, and “rooting depth” could not be addressed as a handicap, while the chemical properties are limited to the problem of salinity.

Table 1 The biophysical criteria for handicaps on agricultural soils and their presence in the Netherlands, based on the study of Smit and Brouwer (2009).

	Criterion	Is a combination of:	Relevant in NL
Climate	Low temperature		-
	Heat stress		-
Soil	Drainage		+
	Texture and stoniness	Coarse material	+
		Coarse/medium sand	+
		Heavy clay	+
		Organic soils	+
		Vertic properties	+
		Rock outcrop	+
		Rooting depth	
	Chemical properties	Salinity	+
		Sodicity	-
Gypsum		-	
Soil & Climate	Soil moisture balance		-
Terrain	Slope		+

After the designation of the less favoured areas on biophysical criteria two further steps are required. The first step is the discussion with the European Commission about the selection of data and the applied criteria. For this purpose, the report of Smit and Brouwer (2009) has been discussed with the European Commission and additional information will be provided in chapter 2 of this report to have a clear insight in the Dutch selection of Less favoured Areas.

The second step is the fine tuning of the biophysical selection. Areas should be excluded from the Natural Handicap designation where a) the handicap has been overcome, b) where the agricultural production achieves on average outputs and results comparable to the average in the Member State/Region and c) where there is no risk of land abandonment. The fine tuning on drainage has already been incorporated in Smit and Brouwer (2009). Biophysical criteria should undergo a further control based on production related criteria as the crop yield per hectare, the stocking density per hectare or the gross margin per hectare (EC, 2009). An assessment for fine tuning was performed for dairy and arable farming systems, based on stocking density at the level of municipalities and on statistical data of crop yields at a regional level (Terluin and Voskuilen, 2010). This fine tuning did however not provide enough information to show where these handicaps have been compensated by adaptation in farming systems and management. Another approach was required to assess effects of handicaps on farmers' incomes. Another way to express the difference in production capacity of agricultural soils and the effects of biophysical handicaps is based on the assessment of the gross margin per hectare.

There are various ways to assess economic effects of agricultural production systems. Firstly, on-farm data collection is a useful source and provides good insight in the economic and technical performance. However, it is known that there is a wide variation in performance levels between farms, even under similar conditions. The farmers' management plays an important role in the technical and economic results. Secondly, technical and economic models have been developed, calibrated and validated (Schils et al, 2007; Schreuder et al., 2008). They are widely used to assess the effects of differences in soil conditions as drainage, soil amelioration and the effects of changes in management as nutrients inputs and efficiency, strategic management, etcetera. The advantage of the models is that the wide variation in (quality of) operational management between farmers is eliminated. The

models act also as an analytical tool, because the relationships between inputs and outputs have been uniformly defined and new (technological) developments can be explored.

Besides the appropriate models, a precise definition of the agronomic consequences of the biophysical handicaps at farm level is required. The effects of biophysical handicaps on crop rotation, crop cultivation, grassland management, risks and crop and grass yields have to be defined in detail. The models and the agronomic rationale will be described in chapter 3. The final results of the fine tuning is found in chapter 4.

The combination of mapping on the basis of biophysical criteria and the fine tuning will be discussed in chapter 5.

The goal of this report is

- a) To provide additional information about the selection of Less Favoured Areas on the basis of the biophysical criteria;
- b) To provide a fine tuning of the biophysical selection by assessing and analyzing the effects of the biophysical handicaps on the technical and economic results of arable and dairy farms;
- c) To define the final list and map of Less Favoured Areas in the Netherlands, based on the combination of biophysical criteria and fine tuning.

2 Additional information on the selection of Less favoured Areas

Introduction

The selection of Less Favoured Areas (LFA's) on the basis of the biophysical criteria has been published by Smit and Brouwer (2009). The results of the selection have been discussed in Brussels and additional a number of additional questions have been defined by the committee to clarify the results or to adjust a number of maps. The results will be discussed in this chapter.

1. Adjustment of the drainage map

The drainage map of Smit and Brouwer (2009) also contains a number of areas that are not in agricultural use, such as the 'Associatie Petgaten' and 'Veengebied in ontginning'. The total amount of hectares of the areas identified as 'Associatie petgaten' and 'Veengebied in Ontginning' is 2800 ha. This is 0.75% of the agricultural areas. This will have a small effect on the drainage map. According to the workflow description as presented in the Guidelines (Böttcher et al. 2009) the drainage map (as one of the maps with soil constraints) shows all areas, agricultural as well as non-agricultural areas. It is methodologically not correct to remove the 'associatie petgaten' and 'veengebied in ontginning' that are not UAA and therefore the drainage map was not altered.

2. Harmonize soil categories belonging to medium or coarse sands with the FAO method

One of the sub criteria for texture & stoniness is the abundance of unsorted, coarse or medium sand or loamy coarse sand in the soil profile. The elaboration of coarse or medium sands, as presented in Smit and Brouwer (2009) used the Dutch standard values for these texture classes. The European Committee, however, used the categories based on Nemes et al. (1999). We were asked to check whether the Dutch method did fit within the method as described by Nemes et al.

In the Dutch system, the particle size distributions of the soil units medium or coarse sands are: clay <8%; silt <32,5%. In the upper texture triangle (Figure 1) this corresponds to sand, loamy sand or perhaps sandy loam (see Figure 1).

Within the classes sand and loamy sand, also the particle size of the sand is relevant, since for the criteria of natural handicap, only medium or coarse sand is considered. In the Dutch classification system, within the sandy textural classes two classes are distinguished (i.e. particle sizes <0.210 mm or >0.210 mm). The soil types (as selected for the elaboration of this criterion) all consist of >50% of sand with particle size >0.210 mm. When that information is projected on the lower triangle, it is clear that the selected soils in the Dutch system can be classified as medium sands or coarse sands. This means that, although the Dutch system was different from the method as described by Nemes et al (1999), the same soil types were selected in the elaboration as presented by Smit and Brouwer (2009). The map was therefore not changed.

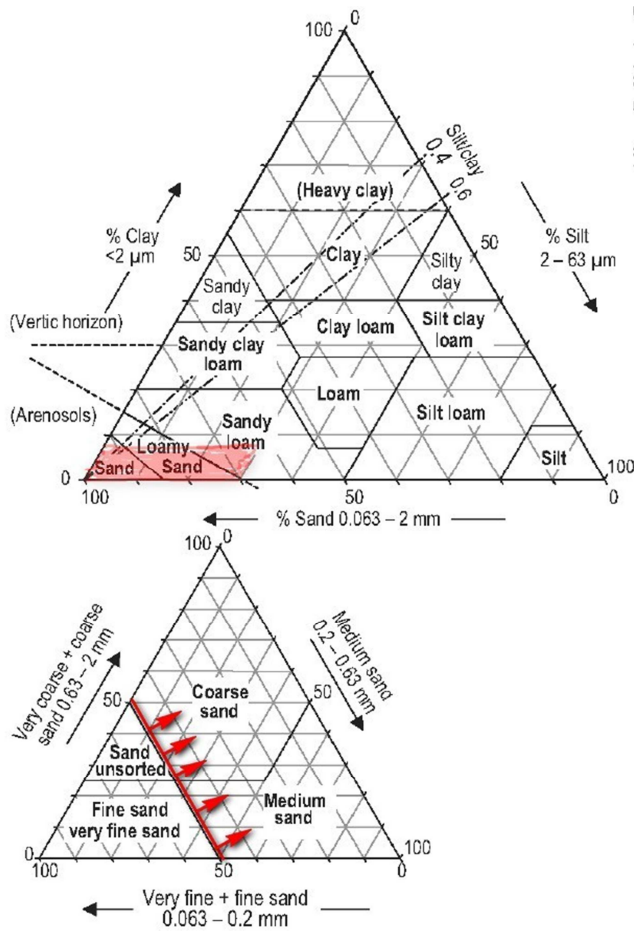


Figure 1 The marked area defines the soil types in the texture triangle that are classified as sandy soils. Within this group of sandy soils, the criteria on particle size > 0.210 mm has been applied, showing that all soils selected within the Dutch classification system are indeed coarse and medium sandy soils.

3. Selection of peat soils

In the elaboration of the criteria on organic soils, grid cells with an organic matter content in the topsoil of >30% were selected. Implicitly, only the upper 30 cm of the soil was considered, whereas this should be a range of 40 centimetres. The soils with thinner peat layers than 40 centimetres should therefore be excluded from the selection.

Changing the minimum range from 30 to 40 centimetres reduced the total area with peat soils by 2886 hectares, which is only 1.5 %. These peaty soils all occur in LAU2-units that are not classified as Less Favoured Areas. This means that the final classification of the LAU2 units that are LFA, is not changed. To give insight in the peat soils on the basis of a minimum thickness of the peat layer of 40 centimetres, a new map is produced (see Figure 2).

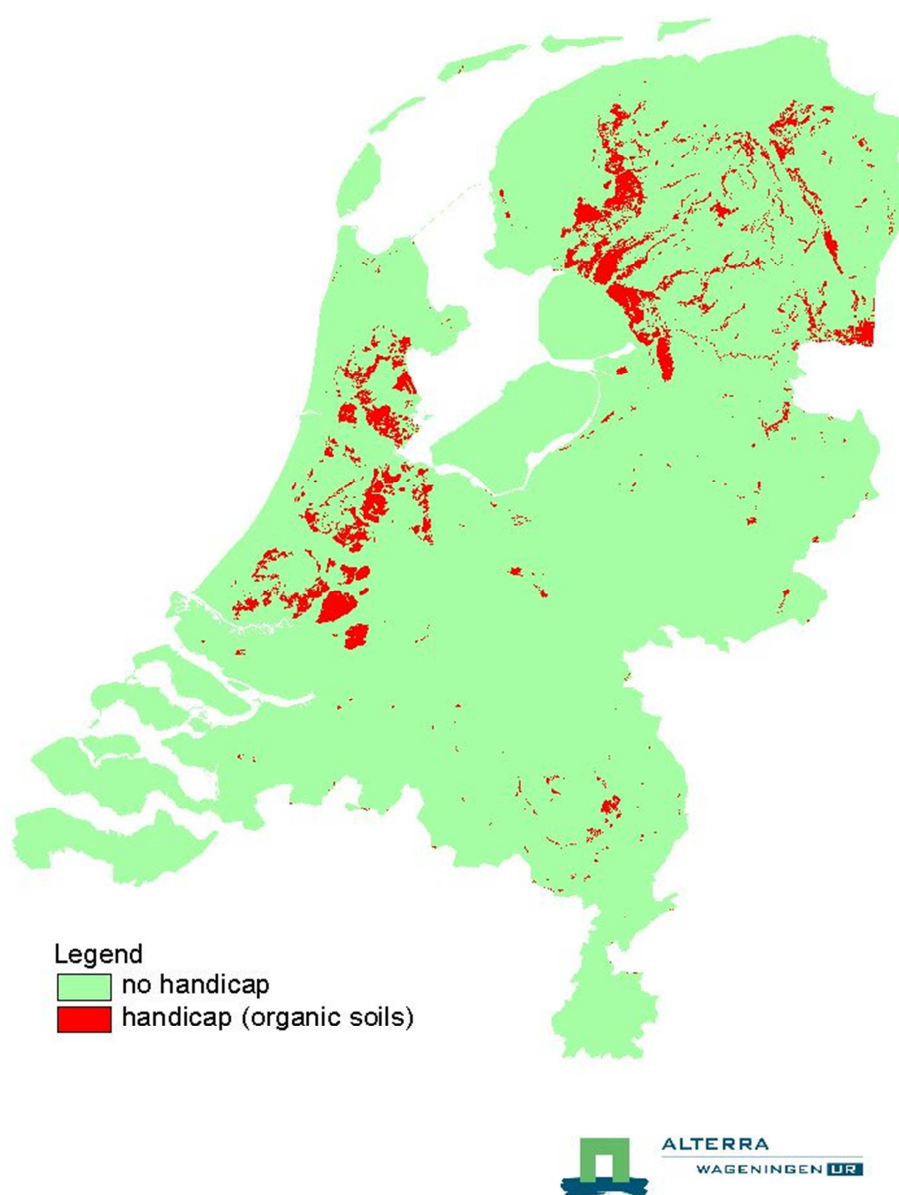


Figure 2 The selected area, applying the criterion of minimal thickness of 40 cm of organic soils. This map replaces figure 5.2.4 in Smit and Brouwer (2009)

4. Peat soils are not considered as vertic soils by the Guidelines

In the elaboration of the selection of vertic soils, Smit and Brouwer (2009) used the description of vertic soils as given by Van Den Akker and Van Putten (1995), but to be in line with the Guidelines, the peat soils have been removed from the selection. This indeed resulted in a decline in the less favoured areas on the basis of vertic properties. However, since peat soils are part of 'texture and stoniness', these soils are already classified as less favoured area by another criterion. So, in the end, there are no differences in the total hectares total of less favoured areas.

5. A clearer definition of slack soils is required

Slack soils appear to occur mainly in non-agricultural areas, although 10075 ha of the total 375701ha distinguished as natural handicap in figure 5.2.5 of Smit and Brouwer (2009) is on slack soils or immature soils. Immature soils are considered part of the soils with vertic properties, because of the cracks in the top soil during dry periods in combination with extreme instability, due to a lack of consistence of the deeper soil layers.

Vermeulen et al. (2003) describe the ripening of immature soils (sediments) as follows: After disposal of clayey sediments, the following spontaneous dewatering processes can be distinguished: sedimentation, consolidation, and ripening. Sedimentation and consolidation are relatively fast processes (within one year), whereas ripening can take up to several years. In a remediation perspective, the ripening of sediments is the most important dewatering process. Ripening, which may be subdivided into physical, chemical, and biological ripening, transforms sediment into soil. Physical ripening is the irreversible loss of water and results in the formation of soil prisms separated by shrinkage cracks.

These soils are formed of marine or fluvial sediments in wet conditions and except for the topsoil (of 20 to 40) the material is more like fluid and flows through the fingers. Due to shallow groundwater levels the spontaneous dewatering process only affects the upper 20 to 40 cm.

6. Saline soils

The EC suggested to change the selection for salinity. In a new selection very high Cl concentrations (>3000 mg/l) are combined with very shallow groundwater levels (< 25 cm below the surface). The area with the biophysical handicap of salinity is strongly reduced by this combination of criteria. Especially the criterion of the shallow groundwater table has a large impact on the total area with a handicap. The new map with less favoured areas by salinity is in Figure 3.

The use of the combination of the above mentioned criteria is not in line with the JRC-report "Common bio-physical criteria to define natural constraints for agriculture in Europe" (van Orshoven et al., 2008). This scientific background on salinization states: 'As saline groundwater comes close to the soil surface (**within 2 m**), salt enters the plant root zone. Even where the groundwater does not bring much salt with it, the waterlogging of the plant root zone alone can damage or kill vegetation.' Chlorine contents just below the top soil can be relatively high and groundwater levels in the Dutch coastal zone are always (relatively) shallow. Groundwater in winter is mostly less than 40 cm deep and during summer less than 80 cm or in 'dry' locations less than 120 cm below the surface.

The discussion about negative effects on yields and farm income will be discussed at the fine tuning in later chapters.

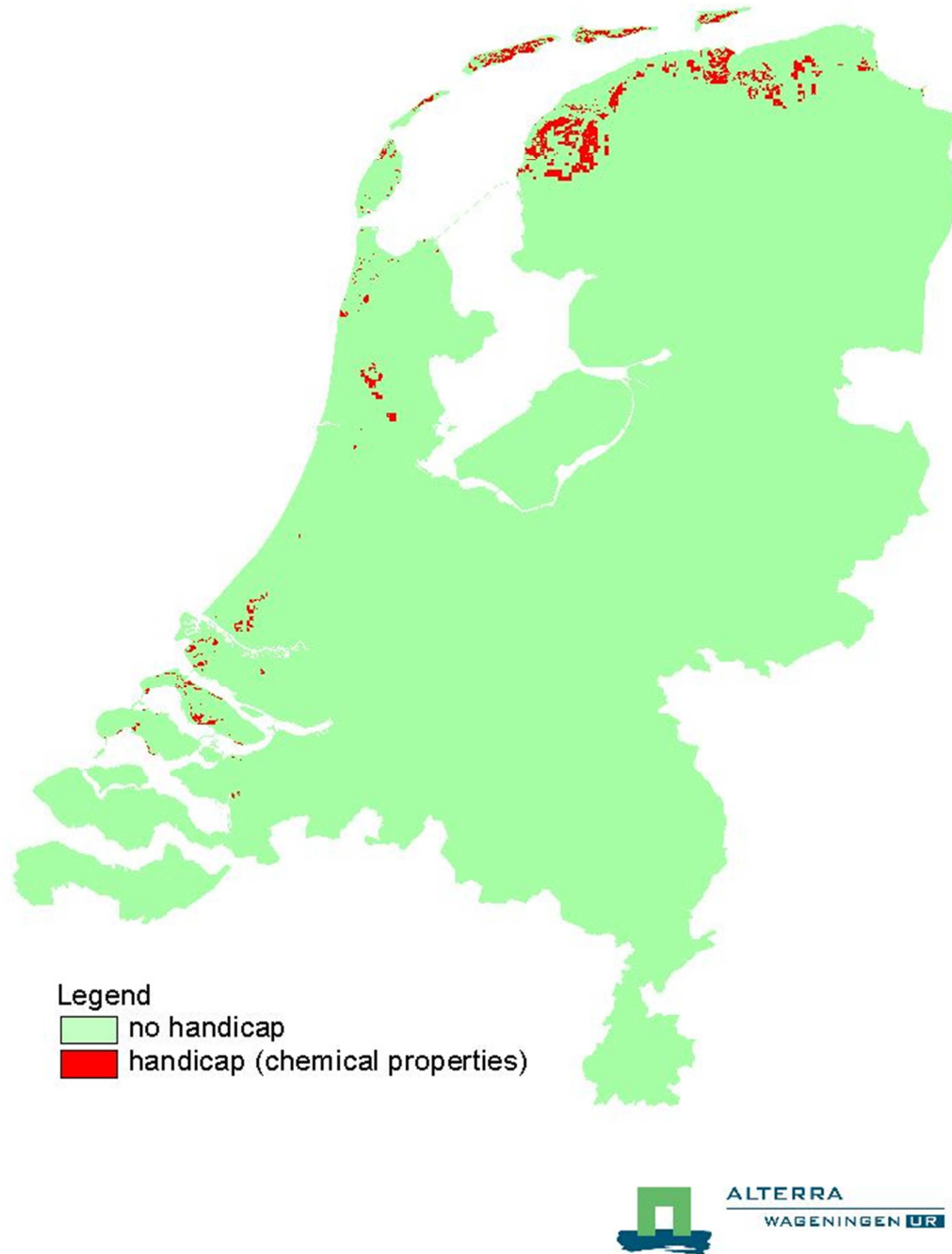


Figure 3 The selected area, applying the criterion of a salt concentration of higher than 2000 milligram/litre and a mean highest ground water table of 25 centimetre below field level. This map replaces figure 5.4 in Smit and Brouwer (2009)

7. Overview of the changes in Less Favoured Areas

The new selection of Less Favoured Areas has its consequences for the area. Table 2 provides an overview of the areas that are selected by applying the biophysical criteria (article 19), or the socio economic criteria (article 20).

The first column shows the biophysical handicaps of article 19. The second column shows the area that is not selected by applying biophysical or socio economic criteria. The “status of this area does not change. The third column shows the area that is selected by applying biophysical criteria only and that have not been selected if socio economic criteria would have been applied. This area changes its status from “normal” to Less Favoured Area. The fourth column shows the area that has been selected by applying socio economic criteria only, but that are not selected by applying biophysical criteria. This area is losing its status of Less Favoured Area. The last column is the area that is selected by applying both sets of criteria and that keeps its status of Less Favoured Area.

Table 2 The area that is not selected by applying biophysical and socio economic criteria, selected by applying biophysical criteria, selected by applying socio economic criteria and selected in both cases. The total area on the basis of applying all biophysical criteria has an overlap and is not the sum of the four lines above.

Handicap	No handicap for both articles	Natural handicap (art.19) no handicap for art.20.	Handicap for art.20 no natural handicap (art.19)	Handicap for both articles
	no changes	increase of LFA	decrease of LFA	no changes
Drainage	3 013 562	246 741	105 977	126 388
Texture and stoniness	2 657 609	602 695	131 646	100 720
Chemical properties	3 094 642	165 661	225 972	6 394
Slope	3 255 162	5 141	231 099	1 266
All criteria	2 392 818	867 485	76 598	155 768

3 Methodology

This chapter will provide:

- an overview of the identified less favoured areas;
- the basic principles for the comparison of technical and financial results between less favoured areas and reference values, including a description of the agronomic effects of the biophysical handicaps in the identified areas and a description of the relevant farming systems;
- the description of the technical and farm economic models that will be used to calculate the technical and economic performance of the selected farm types.

3.1 The identification of less favoured areas

A selection of the biophysical handicaps that have been identified will be used for fine tuning. These are shown in Table 3.

Table 3 The biophysical criteria for handicaps on agricultural soils, their presence in the Netherlands, based on the study of Smit and Brouwer (2009) and the cases that will be elaborated in the fine tuning calculations

	Criterion	Is a combination of:	Relevant in agricultural areas (UAA) in NL	This study	
Climate	Low temperature		-	-	
	Heat stress		-	-	
Soil	Drainage		+	-	
	Texture and stoniness	Coarse material		+	-
		Coarse/medium sand		+	+
		Heavy clay		+	+
		Organic soils		+	+
		Vertic properties		+	+
		Rock outcrop		+	-
	Rooting depth		-	-	
	Chemical properties	Salinity		+	+
		Sodicity		-	-
Gypsum			-	-	
Soil & Climate	Soil moisture balance		-	-	
Terrain	Slope		+	-	

The focus will be on two criteria: Texture and Stoniness and Soil Chemical Properties. Since coarse material and rock outcrop are not relevant within the areas with actual agricultural use, this study focuses on the areas where coarse/medium sands, heavy clay, vertic properties and organic soils are a biophysical handicap. The most important regions, identified in the report of Smit and Brouwer (2009) are:

- Sandy soils in the northeastern part of the Netherlands, mainly in use for arable cropping;
- Heavy clay soils in the north eastern part of the Netherlands, partly in use for arable cropping;
- Peat soil in the western and northwestern part of the Netherlands. The dominant land type is dairy farming based on pure grassland systems;
- Vertic soils; on clay soils in the northern part and the central of the Netherlands, mainly in use for dairy farming; on peat (veenkoloniale) soils in the northeastern part of the Netherlands, mainly in use for arable cropping;
- Saline clay soils in the southwestern part of the Netherlands, mainly in use for arable cropping.

The selected regions for calculation of the agronomic effects are listed in Table 4.

Table 4 The biophysical criteria for handicaps on agricultural soils, their presence in the Netherlands, based on the study of Smit and Brouwer (2009) and the cases that will be elaborated in the fine tuning calculations

Handicaps	System	Municipality or region with handicaps
Coarse/medium sand	Arable	Region Veenkoloniën
Heavy clay, vertic properties	Arable	Region Oldambt
Organic soils	North: Dairy West: Dairy	e.g Boarnsterhim Krimpen aan den IJssel
Salinity	Arable	Province of Zeeland
Vertic soils	Northwest and central: dairy Northeastern: arable	e.g. Boarnsterhim Region Veenkoloniën

3.2 Basic principles for fine tuning

3.2.1 Farming systems and financial results

- Negative effects in less favoured areas that have been compensated in the farming systems by management or farm structure will be incorporated in the calculation. The final result of negative effects from handicaps and positive effects from compensation will be considered;
- Representative, standardized farm types will be used to ensure that the results are applicable to the vast majority of farms;
- Financial results are expressed as gross margin per hectare. In the case of arable crops, EU subsidies are not included;
- It is not yet clear what will happen with the payments after 2013. So, future changes in agricultural policy are not considered.

3.2.2 Reference values and typical agronomic effects

The choice of a reference for comparison and estimating effects of a handicap is always complicated, it is hard to find a perfect comparison. It is obvious that a comparison with the most optimal production conditions as the reference should be avoided. That would overestimate the effects of the handicaps. The comparison should be based on an average value of the member state or the region.

The model approach provides a possibility to calculate the effect of a handicap by defining a virtual reference, where only the handicap factor and its typical (negative and positive) agronomic effects are eliminated. The other production factors are kept constant. It implies that the drainage situation is not changed, implying that the overall negative effects such as growth limitation by drought and workability problems by water surpluses are kept constant. The typical agronomic effects that are related to the before mentioned handicaps are listed below.

Coarse and medium sand:

- a) the susceptibility for wind erosion, leading to the loss of seedlings and to the need of reseeding;
- b) Prevention of wind erosion costs extra labour, machine work and seed materials;

Heavy clay soils:

- c) extra workability problems under dry and wet conditions. The heavy clay soils are confronted relatively soon with reduced workability under wet conditions, due to the limited drainage capacity of the heavy clay soil itself. Under dry conditions, the clay particles can become as hard as concrete. Under normal conditions, extra work is required for a proper seed bed preparation;
- d) the stronger negative effects of workability severely limits the possibility to grow crops such as potatoes and sugar beet, which in general have a higher gross margin per hectare. The high risk of strong yield reductions and of inability to harvest makes it hardly possible to grow these high margin crops and farmers grow cereals every year;

Organic soils:

- e) the stronger negative effects of water surpluses due to the lower bearing capacity of organic soils, leading to higher losses with grazing and cutting;
- f) the extra delay of the start of the growing season of a number of days. With an average grass production of 150 – 200 kg of DM per ha per day, this leads to a loss of several hundred kilograms of dry matter per hectare;

- g) the agronomic poorer botanic composition leading to a lower digestibility of herbage of 5 %. Grassland renovation, if possible, does not lead to satisfactory results. So, on peat soils, grassland renovation is excluded;
- h) the inability to grow maize, which is a high yielding crop with a very constant high energy content;
- i) The smaller paddocks and the inability to increase its size;

Vertic soils:

- j) The cracking of soils during dry spells, and the “swelling” in case of precipitation has two effects. First, after a dry spell, part of the rainwater is lost via the soil cracks (shortcuts). Second, “swelling” might damage plant roots, leading to decreased growth and in the worst case to plant death. Effects are larger on soils with strong vertic properties;

Saline soils:

- k) The suboptimal irrigation of crops, due to the saline or brackish ground- and surface water;
- l) The limited options for irrigation on saline susceptible crops;
- m) When the brackish groundwater is coming closer to the surface, the possibility to grow arable crops is severely limited and for other crops the yield is reduced.

3.3 Detailed description of the farming systems

3.3.1 Coarse/medium sand



Figure 4 Coarse sand, susceptible for wind erosion. The landscape is very open and soil organic matter contents are low. The vague horizon is caused by soil particles, blown by the wind.

Agronomic effects

The sandy soil is mixed with remains of a former peat top layer. A stable soil structure is lacking and the sand is very vulnerable to wind erosion. The landscape is characterized by large scale fields and openness. Surface manure application was used to prevent wind erosion, but this is not practiced anymore, due to the mandatory shallow injection. Another option to prevent wind erosion is sowing winter barley, which is spray killed after emergence. This costly measure is not always successful and wind erosion occurs at a regular basis. Main problems with wind erosion occur at:

- Especially sugar beet production. Small seedlings are very vulnerable;
- All other crops to a lesser extent. Loss of fertile topsoil, fertilizer and pesticides and the occurrence of soil diseases;
- Wind erosion can cause damage to neighbouring fields, leading to yield decrease on neighbouring farms;
- A non-agronomic effect is the dust problem in villages in this region.

Both the effects of wind erosion and its prevention will be calculated.

Dairy farms have a large fraction of permanent grassland, which makes them much less vulnerable to wind erosion. Therefore no dairy farms are considered for this handicap.

Reference farms

Table 5 The technical farm parameters for the calculation of the effects of coarse and medium sand on the gross margin per hectare

Agricultural system	Less favoured area	Reference value
Arable production	Hoogezand Sappemeer	-
Farm size (ha)	80	80
Winter wheat (%)	5	5
Summer barley (%)	25	25
Sugar beets (%)	20	20
Starch potatoes (%)	45	45
Seed potatoes (%)	5	5
Extra costs erosion prevention	Barley/Compost	0
Effects wind erosion	Yield reduction sugar beet	0
	Yield reduction other crops	0
	Dust problem vicinity	0
	Damage to neighboring farms	0

3.3.2 Heavy clay

Agronomic effects

The clay soils have a very high clay fraction (> 60 %), which makes them hardly suitable for growth of potatoes and sugar beets. When these crops are grown, risks of severe yield reduction or the impossibility to harvest are high, compared to soils with a lower clay fraction. Soil cultivation is complex and requires more preparation and activities than soils with a lower clay fraction. The farms in the heavy clay region have compensated the handicap partly by increasing the farm size. This was possible by the relatively low labour demand for cultivation of cereals.

Dairy farms consist of a combination of grassland and land for maize, which makes them suitable for heavy clay soils.



Figure 5 Cereals are the most common crops on the heavy clay soils of the North of the Netherlands. Cultivation of potatoes and sugar beet is almost impossible

Reference farms

Table 6 The technical farm parameters for the calculation of the effects of very heavy clay (>60 % clay) on the gross margin per hectare

Agricultural system	Less favoured area	Reference region
Arable production	Reiderland	Eemmond
Farm size (ha)	120	60
Winter wheat (%)	60	30
Summer barley (%)	0	5
Winter barley (%)	15	0
Sugar beet (%)	15	20
Rape seed (%)	10	0
Consumption potatoes (%)	0	20
Onions from seed (%)	0	10
Peas (%)	0	5
Gras for seed production (%)	0	10
Green manure (%)	15	20
Extra labor and machinery for cultivation	+	-

3.3.3 Organic soils

Agronomic effects

Due to higher ground water tables and the physical conditions of organic soils compared to mineral soils, the bearing capacity of peat soils is lower compared to mineral soils. Due to the wetter conditions, grass growth in spring is delayed with four to five days. Agronomic affects, compared to mineral soils are:

- grazing of dairy cows and cutting for silage both start later in spring;
- the end of the grazing season is about one week earlier;
- Botanic composition of grasslands is worse, leading to a reduction in herbage digestibility;
- Rainy periods affect bearing capacity stronger. So, on average, grazing losses are higher and in case of cutting, silage making takes one day extra;
- Maize production is not possible;
- Larger risks and higher frequency of sward damage by machinery and cattle;
- Drainage requires narrow paddocks, with a fine network of ditches. It is impossible to merge paddocks;
- A higher soil N supply, although this is not realized on all peat soils.

Arable farms are not found on organic soils, due to the inability to cultivate the land.



Figure 6 Typical peat soils in the western part of the Netherlands. Width of paddocks is mostly about 40 meters, due to drainage requirements. The groundwater table is relatively high.

Reference farms

Table 7 The technical farm parameters for the calculation of the effects organic soils on dairy farms in the western and northern peat regions of the Netherlands on the net gain per hectare. Data from Aarts et al. (2008)

Agricultural system	Less favoured area	Reference region	Less favoured area	Reference region
		Northern peat region		Western peat region
Dairy production				
Milk per farm (kg)	750 000	750 000	650 000	650 000
Milked cows (-)	94	94	81	81
Milk per cow (kg/cow)	8000	8000	8000	8000
Area grass (ha)	60	55	51	46
Area maize (ha)	0	5	0	5
Grazing system (-)	Day & night	Day & night	Day & night	Day & night
Supplement during grazing (kg Dm/cow)	Grass silage, 3 kg	Maize silage, 3 kg	Grass silage, 3 kg	Maize silage, 3 kg

3.3.4 Vertic soils

Agronomic effects.

Vertic soils shrink and swell during dry and wet spells. When it starts raining after a dry spells, the large and deep cracks transport the rain water immediately out of the root zone. This process of shortcuts reduces the available water for crop production and subsequently leads to yield reduction. Soil swelling starts slowly and cracks are closed again. This process of swelling can lead to root damage, causing growth reduction or, in case of severe swelling and shrinking, to plant death. This process is especially strong with arable crops with a deeper rooting system. The high moisture capacity of this type of soils compensates the negative effects. The negative effects with yield reduction or crop damage are of limited relevance in the Netherlands, according to researchers and other experts.

The very heavy clay soils with vertic properties are grasslands. Grassland is facing less problems with vertic soils. The vast majority of grass roots is in the top 5 to 10 cm, and soil organic matter of the top 10 cm is higher compared to arable crops. This means that shortcuts of precipitation occurs, but that root damage is hardly found.



Figure 7 The picture shows an extreme example of vertic properties on an immature soil. The effects on mature soils are often less pronounced

3.3.5 Salinity

Agronomic effects.

Salinity is expressed by the presence of saline or brackish groundwater. There is a wide variation in susceptibility for brackish or saline conditions (Van Dam et al., 2007). Problems with salinity are limited in almost all regions, due to the fact that fresh surface water is present, in the coastal and peat regions by active transport by the water boards, and the fact that the precipitation surplus of the previous winter is partly stored in the topsoil, depending on the water storage capacity of the soil. It means that plants partly grow in fresh water.

Only in dry spells, saline problems do occur. There are two options, firstly irrigation with brackish water for the less vulnerable crops, accepting that the positive effects of irrigation are partly counteracted by the brackish conditions of the water and secondly no irrigation for the vulnerable crops. In regions where salinity doesn't occur, fresh water supply can also be limited because other water related goals have priority. Potatoes cannot be irrigated with surface water anyway for phytosanitary reasons, also in regions where fresh water is present. It implies that limitations in irrigation are not specifically limited to saline regions of the Netherlands. In dry years, yield reduction is often compensated by higher commodity prices.

The less vulnerable arable crops for saline or brackish conditions are: winter wheat, other cereals and sugar beet (Van Dam et al., 2007). The fractions of these crops are on average 39, 19 and 12 % respectively. So, in total 70 % of the cultivated areas consists of less vulnerable crops. The fraction of vulnerable crops is on average 30 %, consisting of potatoes for consumption (19 %), seed potatoes (4 %) and seed-onions (7%). Because irrigation of potatoes is already limited due to phytosanitary reasons, only onions might suffer from limited possibilities in irrigation.

In general it is expected that there will be limited negative effects on crop production by brackish or saline conditions.

Grassland is much less vulnerable than arable crops to brackish or saline conditions. It is recommended that livestock should not drink brackish water in dry spells, due to the increased salt concentration. In almost all situations, fresh water is already supplied to livestock, for reasons of animal health and food safety. Therefore no negative effects on dairy farms will be expected.



Figure 8 Problems with salinity are often combined with relatively low fields or parts of fields, compared to the direct vicinity. The problems with water surpluses are often more important than the salinity.

3.4 The use of models

3.4.1 Dairy Wise

Farm model calculations for dairy systems were carried out with DAIRYWISE (Schils et al., 2007a). DAIRYWISE is a full accounting model, taking into account a) soil properties as drainage, texture, drought sensitivity, soil N supply; b) land use and management as grass and feed crops, application of manure and chemical fertilizers, grazing system; c) livestock properties as milk production per cow, replacement rates, feeding strategy and d) other technical issues as housing, manure storage and mechanization. The model accounts for a number of interactions between the afore mentioned 4 categories. The technical and financial results are based on the simulation of grass and crop production, grassland management and animal nutrition. Model calibration and validation has been documented (Schils et al., 2007a) The farm economic results, based on standardized prices are updated annually (Vermeij et al., 2010). All technical results and the nitrogen fluxes are used to calculate the emissions of CH₄, N₂O and CO₂ (Schils et al., 2007b).

3.4.2 MEBOT

The model structure of MEBOT is based on that used for DAIRYWISE, the Dutch farm model for dairy farms Schils *et al.* (2007a). In the input, crop and farm data are collected, either by manual input or by using standard values from a database. The procedure generates an input file for the calculations. In this part technical, environmental and economic output is produced which is used for making reports. MEBOT is set up as a modular model giving users the opportunity to use only those modules which are relevant for their calculations.

MEBOT builds up a farm from the separate crops on the fields and their accompanying operations necessary for optimal crop growth (ranging from pre-planting operations like ploughing till post-harvest operations like stubble treatments). A crop operation is defined as the whole of the time of application (day), the amount of used products and the used machinery. The model simulates the yields and costs and the processes in plant, soil, water and air on a crop level. Consequently, the results on the field and farm level are given by the sum of the results of the separate crops on a certain field or the farm respectively. Technical details on crop production, cultivation, fertilization and environment are described by Schreuder et al. (2008).

Model input

In the input part all crop and farm data are collected necessary for the calculations. Required data apply to soil properties, crop rotation, fertilizer recommendations, crop operations, marketable yields, prices and nutrient content of products, labour requirement and economical properties of machinery, buildings and services. For all data standard values are given which can be adjusted manually. The standard values for crop operations and prices of products and services are derived from Schreuder et al. (2009). Using the standard option can be convenient for scenario studies which are commonly based on representative standard farms. In that situation only the crops on the different fields have to be assessed. For more specific calculations for example with regard to existent commercial farms, depending on the aim of the study, to a greater or lesser extent the standard data have to be adjusted manually to get realistic results.

4 Results

4.1 Economic effects of handicaps

4.1.1 Coarse/medium sand

As mentioned before, wind erosion is mainly a risk for the production of sugar beet. The proportion of sugar beet in the crop rotation is 20 %. The costs of the production loss can be calculated in two ways. The first is to accept the loss. On average 10 % yield reduction occurs, compared to the reference farm, based on the practical experience of experimental farms and of extension workers. All activities as ploughing, seedbed preparation, harvesting remain the same. The average financial yield per hectare of sugar beet is € 2167 (Schreuder et al., 2009). A yield reduction of 10 %, without a reduction in production costs, reduces both the financial yield and the gross margin with € 217 per hectare of sugar beet. Per hectare of farm area this is $(16 \times 217) / 80 = € 43.40$.

The second option is to prevent wind erosion by sowing summer barley. The total costs of sowing are shown in Table 8. The costs per hectare of farm area are $(16 \times 192) / 80 = € 38.40$. Sowing barley is not always effective. In the case of poor development of barley and unfavourable wind conditions in late spring (north to north-western winds), severe damage can occur, despite preventive actions. Both calculation methods show similar results, the average costs are € 40.90 per hectare of farm area.

Table 8 The costs of sowing summer barley to prevent yield reduction in sugar beet by wind erosion

Activity/input	Costs (€ per ha)
Seed costs	89
Spray killing in low-dose-system	23
Pesticide application (0.31 h)	20
Sowing (1 h)	60
Total costs per hectare of sowing barley	192

Beside the costs of erosion by yield reduction or prevention, losses of fertilizers, pesticides and fertile top soil occur. This happens on all agricultural soils. No detailed costs of this are known from farms. A rough estimate of a loss of 5 % (in half of the occasions of yield reduction by wind erosion) is used. The average costs of synthetic fertilizer application and of pesticide application are € 316,- and € 391,- per hectare, respectively (Schreuder et al., 2009). Costs of loss of top soil are not calculated. The financial loss of 5 % is: $(316 + 391) \times 0.05 = € 35.35$ per hectare.

Total financial losses of wind erosion are $€ 40.90 + € 35.35 = € 76.25$ per hectare of farm area.

4.1.2 Heavy clay

Calculation with the two farm types as defined in Table 6 show a lower gross margin per hectare on heavy clay soils of € 192.40 per hectare lower compared to the situation where the limitations of the heavy clay have been eliminated. The difference in gross margin can be explained by:

- The financial yield per hectare of the reference farm is almost twice the yield of the heavy clay farm, but the direct costs are higher as well. Due to the farm size, there is only a small difference in the total financial yield, but the reference farm has lower costs. This effect explains € 59 of the difference in gross margin;
- The continuous grain cropping will lead to a yield reduction due to crop related diseases. It is known that this can go up to about 20 %, but on the long term this stabilizes at about 10 % (Ruud Timmer, personal communication). This yield reduction explains € 108 per hectare;
- The winter wheat is sown immediately after the harvest of the preceding crop. At that moment the soil is still very dry and hard. On average, one extra seedbed preparation is required. In very dry conditions this can go up to 2 or 3 extra preparation activities, under profitable conditions the extra seedbed preparation is not necessary. Due to the high labour demand at the period of harvest and immediate seedbed preparation, external labour is required. The extra labour and fuel costs per hectare are € 26,-.

Total financial losses of heavy clay are $€ 58.90 + € 107.70 + € 25.70 = € 192.30$ per hectare of farm area.

4.1.3 Organic soils

The disadvantages of peat soils compared to other soil types are the poorer botanical composition and the higher losses at grazing and cutting. The net energy yield of grassland on peat soils is about 10 % lower compared to the reference situation, the effects are similar for both peat regions (Table 9). As a consequence of the lower net energy yield on the farms with handicaps, the situation of a surplus of roughage on the reference farm switches to a shortage on the farm on peat soil. Due to the poorer roughage quality on the farm with handicaps, more concentrates per animal are required (Table 9)

Table 9 Technical data on grassland yield, grazing, roughage and concentrates of dairy farms with and without natural handicaps on peat soils in the northern and western peat regions of the Netherlands

	Northern peat		Western peat	
	Handicaps	Reference	Handicaps	Reference
Net grassland yield (MJ net energy/hectare)	63 080	69 607	64 853	71 560
Grazing period (days)	168	174	172	178
Buying roughage (ton DM/farm)	4		1	
Selling roughage (ton DM/farm)		35		34
Concentrates (incl. young stock) (kg/cow)	2046	1640	2049	1624

The poorer results of grassland on peat soils, the shorter grazing period and higher inputs of concentrates are reflected in the financial results. The financial yield on peat soils is € 73 to 86 lower compared to the reference farm (Table 10). The reason is that no roughage is sold on the peat farms and no premium for maize was received in the past. The direct costs on peat soils are € 66 to 73 higher than on the reference farms, which is mainly caused by higher costs for concentrates. The indirect costs are a little bit higher on the peat soils (€ 11 to 18 per hectare), caused by slightly higher costs for fuel and field roads.

The overall financial results on peat soils are € 150 to 177 per hectare lower, compared to the reference farms (Table 10).

The calculations have been based on a Soil Nitrogen Supply of 300 kg N per hectare per year. In those occasions where the Soil Nitrogen Supply is lower, the differences in financial results between peat and mineral soils will be larger.

Table 10 The differences in financial results of dairy farms with and without natural handicaps on peat soils in the northern and western part of the Netherlands

Results of Reference situation compared to LFA (€ per hectare)	Northern peat	Western peat
Financial yield	- 73	- 86
Direct costs	+ 66	+ 73
Indirect costs	+ 11	+ 18
Gross margin	- 150	- 177

4.1.4 Saline soils

Problems with saline soils on arable farms are limited. From a consultation of scientists from plant and environmental sciences it can be concluded that:

- Salt or brackish water is present in deeper layers below the rooting zone, but due to the precipitation surplus in winter a fresh water lens is present in the top layer and is available for crop production;
- Problems with seeping of saline water are mostly local and field specific. It is related to lower fields or parts of it. In that case the wet field conditions are a larger problems than the saline seepage;
- At this moment water boards provide fresh water to reduce the salinity of ditches. Problems can occur on a local basis, when not enough fresh water can be supplied during very dry spells;
- Irrigation of potatoes with surface water is prohibited in many regions (saline and non saline), due to phytosanitary reasons (Bruinrot);

- In case irrigation is possible during very dry spells, irrigation with brackish water is preferred above no irrigation at all. A regional study showed that irrigation with brackish water (2 grams Chloride per litre) increased the yield of potatoes, irrigation water with 4 grams of chloride per litre caused yield reductions. So, even a vulnerable crop as potatoes can be irrigated with brackish water. Less problems with brackish water are expected with wheat and sugar beet. (Van Bakel and Stuyt , 2010; Bakker and Van der Galiën, 1969).

A consultation of 15 dairy farmers in saline regions of the Netherlands also leads to the conclusion that salinity is almost no problem. Problem only occur in case of local differences in field level. In that case the wet conditions are a larger problem than the salinity, similar to the arable crops.

It can be concluded that at this moment saline problems only occur to a limited extent. However, in the future with increasing sea water levels and when “washing” the water system with fresh water will be limited, it can be expected that salinity problems will increase.

4.1.5 Vertic properties

Vertic properties are well known on heavy clay soils. On heavy clay soils, dairy farming is the most common land use type. Dairy farmers grow grass and maize and do not face problems in relation to the vertic properties. However, conditions might be not as good as on the lighter clay soils or on the sandy soils, it is assumed that the limited handicap has been overcome.

When arable farming is practiced on heavy clay soils, problems with vertic properties are very limited. Other problems on heavy clay soils are more important, as is shown in paragraph 4.1.2. Although theoretically the vertic properties can be expected on peat soils in the south-eastern part of Drenthe and Groningen, the problem is not recognized by the experimental farm and other arable specialists.

It can be concluded that vertic properties do not lead to a lower gross margin compared to reference situations without vertic properties.

4.2 Final assessment of less favoured areas

All results of paragraph 4.1 are summarized in Table 11. It can be concluded that the handicaps coarse/medium sand with wind erosion, heavy clay with limitations in crop rotation and organic soils with lower grass quality and higher utilization losses lead to a lower gross margin per hectare and that the negative effects have not been overcome.

In the case of vertic properties and salinity, some negative effects have been identified. But they are expected not to lead to a lower gross margin per hectare in the calculations.

Table 11 The lower gross margin per hectare related to handicaps on agricultural soils

	Criterion	Is a combination of:	Relevant (AAU) in NL	Lower Gross Margin in LFA
Climate	Low temperature		-	-*
	Heat stress		-	-
Soil	Drainage		+	-
	Texture and stoniness	Coarse material	+	-
		Coarse/medium sand	+	76
		Heavy clay	+	192
		Organic soils	+	150-177
		Vertic properties	+	Low
		Rock outcrop	+	-
	Rooting depth		-	-
	Chemical properties	Salinity	+	Low
Sodicity		-	-	
Gypsum		-	-	
Soil & Climate	Soil moisture balance		-	-
Terrain	Slope		+	-

*) in last column - = not assessed

5 Final assessment of Less Favoured Areas

The fine tuning showed that the agronomic consequences of the biophysical criteria “Coarse and medium sand”, “Heavy clay” and “Organic soils” lead to lower gross margins per hectare. The agronomic consequences of saline soils and soils with vertic properties do not lead to significant lower gross margins. It should be noticed that for saline soils this is true under the current conditions where water boards are able to supply sufficient fresh water during the growing season. It is unknown what the effects of sea level rise and the lack of fresh water will be in the future.

The combination of the selection on biophysical criteria and of the fine tuning results in a new list of municipalities where more than two third of the Agricultural land belongs to the less favoured areas. This is shown in Table 12.

Table 12 Municipalities (LAU2-units) where at least 66% of the agricultural land is designated as Less Favoured Area

LAU2-unit (municipality)	% of UAA indicated as LFA	LAU2-unit (municipality)	% of UAA indicated as LFA
ROZENDAAL	99.7	LAREN	82.8
REEUWIJK	99.4	WATERLAND	82.7
BOSKOOP	99.2	WOERDEN	82.6
OOSTZAAN	98.9	BAARN	82.3
OUDER-AMSTEL	98.3	WORMERLAND	81.3
SLIEDRECHT	98.3	LEMSTERLAND	79.5
VLIST	98.1	MOOK EN MIDDELAAR	79.4
LANDSMEER	97.1	BREUKELEN	79.1
BERGAMBACHT	97.0	VOORSCHOTEN	79.0
GOUDA	96.6	MOORDRECHT	78.8
PAPENDRECHT	96.5	BERGEN LB	78.0
NIEUW-LEKKERLAND	96.2	GRAFT-DE RIJP	77.7
DIEMEN	96.1	HARDINXVELD- GIESSENDAM	77.3
DE RONDE VENEN	95.2	CAPELLE AAN DEN IJSSEL	77.1
NEDERLEK	94.7	ALPHEN AAN DEN RIJN	77.1
ZEEVANG	94.6	BODEGRAVEN	76.5
NIEUWERKERK AD IJSSEL	92.7	KRIMPEN AAN DEN IJSSEL	75.2
HUIZEN	92.3	MAARSSSEN	74.3
OUDERKERK	91.5	OUDEWATER	72.7
BLARICUM	91.1	SKARSTERLAN	69.7
EEMNES	90.5	SCHIEDAM	69.4
GRAAFSTROOM	88.4	TERSCHELLING	68.8
BUNSCHOTEN	87.6	RHEDEN	68.1
RENKUM	86.8	HEEMSTEDEN	66.8
LIESVELD	84.5	MUIDEN	66.3
AMSTERDAM	84.4	WESTERVOORT	66.2
		WYMBRITSERADIEL	66.2

The total area belonging to less favoured areas is shown in Figure 9. In Figure 10 only the Utilized Agricultural Areas (UAA) are shown. The total area of Less Favoured Areas after fine tuning on economic criteria is reduced by about 50%, compared to the assessment on the biophysical criteria by Smit and Brouwer (2009).

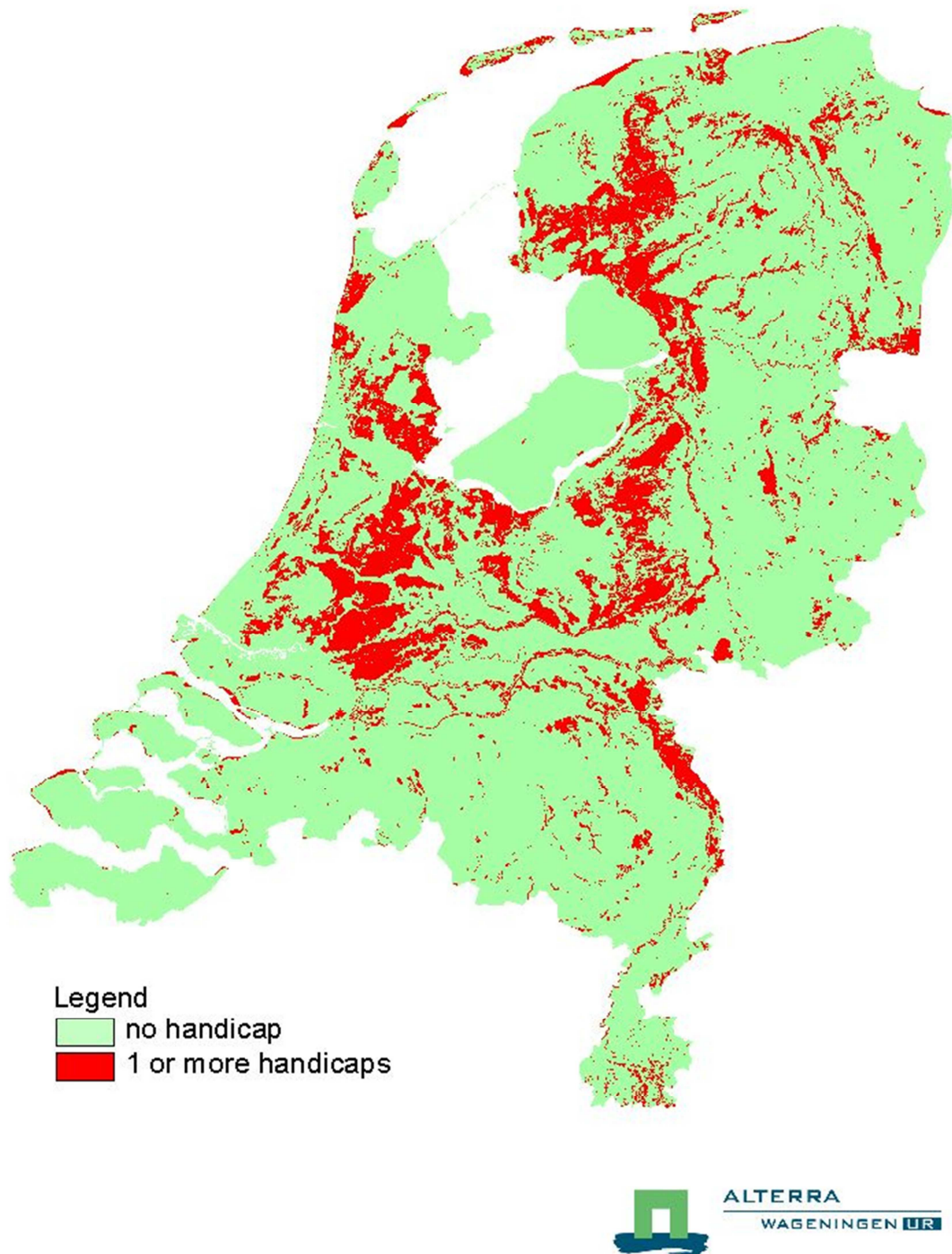


Figure 9 All areas designated as less favoured areas in the Netherlands, based on biophysical criteria and fine tuning on the basis of economic criteria. The map replaces Fig 2-1 of Smit and Brouwer (2009).

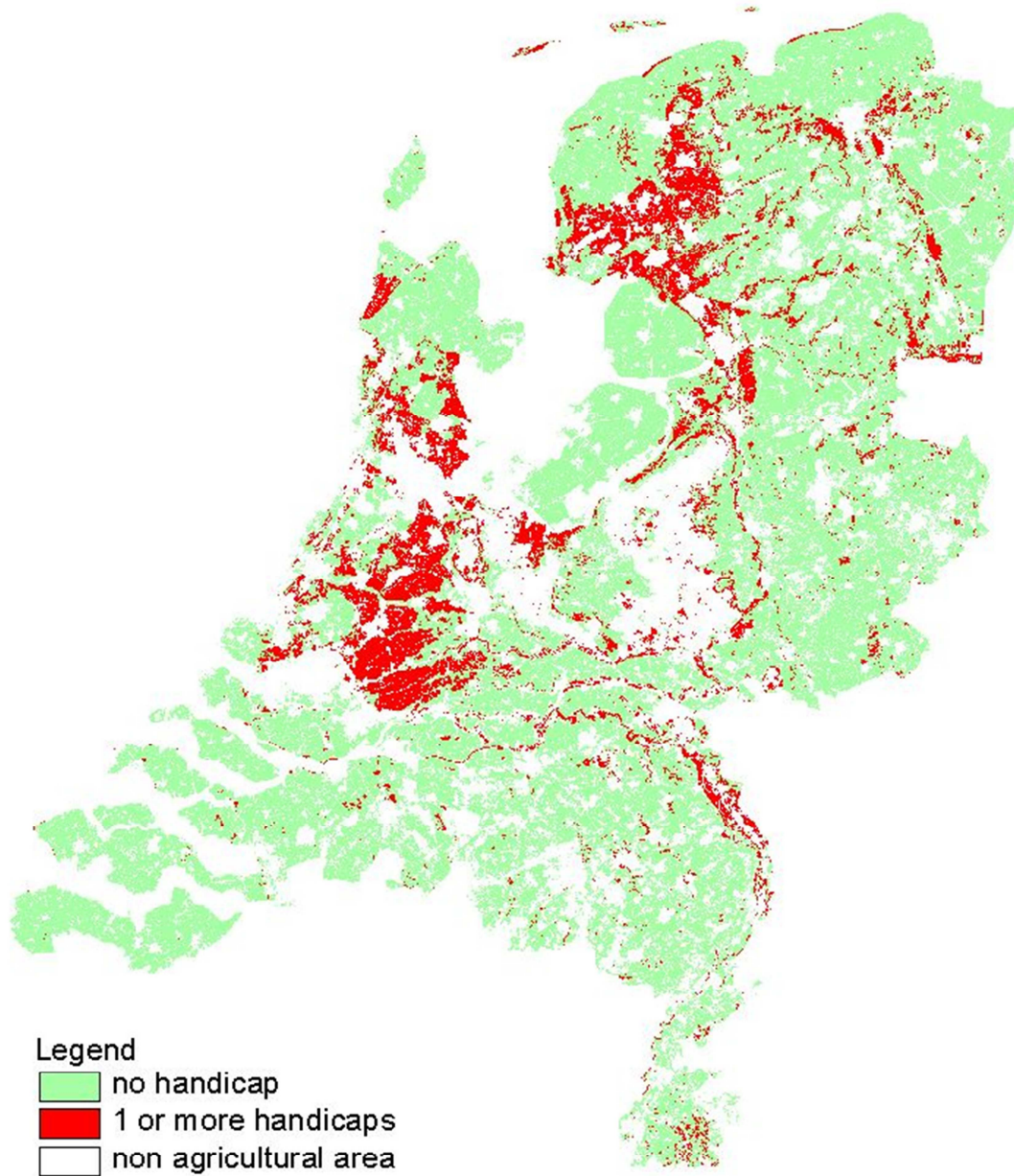


Figure 10 All Utilized Agricultural Areas (UAA) designated as less favoured areas in the Netherlands, based on biophysical criteria and after fine tuning on the basis of economic criteria. The map replaces Fig 2-2 of Smit and Brouwer (2009).

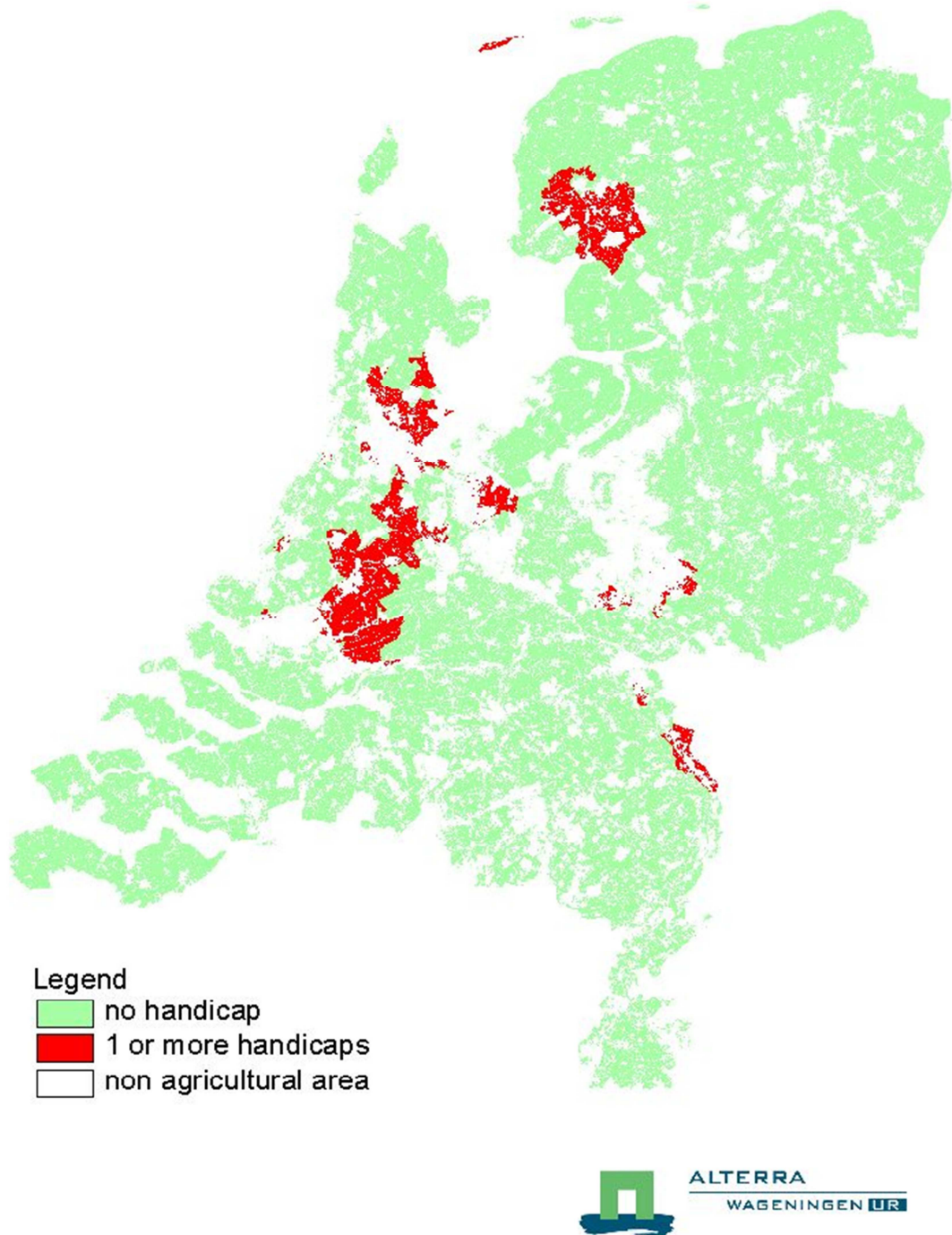


Figure 11 All municipalities (LAU2 units) with at least 66% of the UAA as affected by natural handicaps after selection on biophysical criteria and fine tuning with economic criteria.

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