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METHODS FOR MAPPING SUITABLE AREAS FOR CEREAL PRODUCTION IN THE NORTHERN PERIPHERY REGION

A Project Report

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By

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METHODS FOR MAPPING SUITABLE AREAS FOR CEREAL PRODUCTION IN THE NORTHERN PERIPHERY REGION- A Project Report

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1 Summary

Availability of arable land, which is land that can be ploughed and used to grow crops, is a requirement for any cereal production. In some areas of the northern periphery and artic region, availability of arable land can be a limiting factor for increasing cereal cultivation. The aim of this report is to describe methodologies that can be used to estimate the size of arable land in regions that have limited or outdated information regarding land types and usage. This report will focus on two regions within the northern periphery area, which already have performed estimates of the size of arable land: Iceland and Northern-Norway. We propose that a two-stepped approach in estimating suitable arable land: 1) Choosing the criteria that arable land is defined upon and 2) choosing methodologies and data source for the estimates. Examples on how this can be achieved are given for Iceland and Norway separately. Several different estimates of the size of arable land have been published for Iceland, which range between 3,000 – 15,000 km^2. Arable in N-Norway is considerably smaller and has been estimated to be about 900 km^2. We are certain that the experience gained in these two regions can benefit the northern periphery area as a whole.

2 Introduction

The aim of the Northern Cereal project is to increase barley cultivation in the Northern Periphery and Artic (NPA) region. Availability of arable land, which is land that can be ploughed and used to grow crops, is a requirement for any cereal production. In some regions of the NPA area, availability of arable land can be a limiting factor for increasing cereal production. Therefore, it is important to estimate the total area of land, in the participating regions of the Northern Cereal project, which can be considered arable. A number of conditions must be met for land being defined as arable and suitable for barley cultivation. Factors regarding local climate, soil conditions, pests and diseases are all important. However, their importance in defining land suitable for cereal cultivation will vary between regions within the Northern Periphery Area. The aim of this report is to describe methodologies that can be used to estimate the size of arable land in regions which have limited or outdated information regarding land types and usage.

3 Regions and previous estimates of crop land area

The regions included in the NPA Northern Cereal project are the following: Faroe Islands, Iceland, Newfoundland, Northern-Norway and Orkney. Table 1 shows the current estimates of the size of arable land in these regions.

Table 1. Information on current estimates of the size of arable land in the NPA region. Note that there are three different estimates reported for Iceland (see section 5.1.1).

Region	Total area of region (km^2)	Area of arable land (km^2)	Proportion of arable land (%)
Faroe Islands[1]	1,400	NA*	NA*
Iceland	103,000	15,000[2]	15
Iceland	-	6,000[3]	6
Iceland	-	3,000[4]	3
Newfoundland	108,860**	NA*	NA*
N-Norway[1,5]	113,093	900	0.01
Orkney	990	226[1]	23

*No data available
**Not including Labrador
[1]Reykdal et al. (2014)
[2]Jóhannsson (1960)
[3]Traustason and Gísladóttir (2009)
[4]Sveinsson and Hermannsson (2010)
[5]The Norwegian counties of: Nordland, Troms and Finnmark.

This report will focus on two of these regions, Iceland and N-Norway, and in sections 4 and 5 details are given on how the size of arable land were estimated in these regions.

4 Mapping sutiable land for cereal production

This report proposes a two-step approach in mapping suitable land for cereal production in the northern periphery region:

1) Choosing the criteria on which to arable land is to be defined. This will vary between regions. Examples of definition for arable land used in Iceland and Northern Norway are given in sections 5.1. and 5.2 respectively.
2) Choosing the methods and geographical data sources that will be used to map arable land, based on the definition set in step 1 above. Methods will vary between regions and are highly dependent on the availability and quality of geographical data. In some regions, high quality data regarding land types and soil composition may already exist, whereas in other areas this information could be lacking. Where geographical data is limited, various methods in remote sensing could be utilized to map arable land in an efficient manner (see section 4.2).

4.1 Defining arable land in the Northern Periphery region

4.1.1 An example from Iceland

Several different criteria have been put forward in order define and estimate arable land in Iceland (see Snæbjörnsson et al., 2010). The definition used in the Northern Cereals project for mapping arable land in Iceland, comes from Snæbjörnsson et al. (2010) and Helgadóttir et al. (2011). The following eight conditions must be met in order for a certain area of land to be considered arable in Iceland: (i) land cannot be more than 200 m above sea level; (ii) soil depth must be greater than, or equal to, 30 cm; (iii) wetlands must have sufficient slope to allow for drainage; (iv) sandy areas and deltas are included, with the exception of aeolian sands and glacial sands; (v) slope must be less than 5-10%, depending on soil type, to hinder erosion; (vi) arable land will be defined up to lakes and rivers, but the protection zone will subsequently be subtracted; (vii) the area must have a minimum continuous area of 3 ha; (viii) protected areas are excluded.

4.1.2 An example from Norway

Arable land in Norway is defined as an agricultural land with an adequate soil depth for ploughing, not less than 20 cm, which can be utilized for both arable crops and grasslands

and can be renewed by ploughing. The soil should not include stones that prevent adequate ploughing. Areas which are not currently cultivated but meet the criteria of arable land are registered as arable land within the classification system. In addition to classification of land, the whole country is divided into agroclimatic zones based on its suitability for agricultural production. As a consequence of its geographical structure and position, climate varies considerably within Norway, from south to north and from coast to inland, in addition to local climate differences occur due to topography. The situation for crop production therefore varies considerably within the country. In the 1980s Skjelvåg (1987) divided the country into six agroclimatic zones based on mean temperature from April to July (Table 2).

Table 2. Agroclimatic zones in Norway from Skjelvåg (1987).

Zone	Criteria
1	Suitable for food-cereal
2	Marginal for food-cereal
3	Suitable for feed-cereal
4	Marginal for feed-cereal
5	Suitable for forages grasses (2 harvests)
6	Marginal for forages grasses (1 harvest)

4.2 Choosing methodology and sources of geographical data, an example from Iceland

The methodology for mapping arable land in the northern periphery region depends heavily on the available geographical data in each region. Therefore, it is likely that the methods used will vary considerably between regions. Some sort of remote sensing is likely to be required in some areas, e.g. aerial photography and/or satellite imaging, but those data sources must be complemented with on-site (*in situ*) observation (Sveinsson and Hermannsson, 2010; Gudmundsdottir, 2014). Methods that estimate vegetation cover using NDVI (Normalized Difference Vegetation Index) are especially useful in this context (Gudmundsottir, 2014). With increased accuracy of data acquired by remote sensing and better computational methods of analysing the data obtained, fully automated estimates of arable land could become a reality in the near future (Gudmundsdottir, 2014). The main challenge of relying solely on data obtained from remote sensing lies in estimating the soil depth (see definition of arable land in section 4.1). Adequate soil depth is a major factor

making land arable, since rocks and excessive gravel hinder ploughing. In section 5, examples will be given on how the most current estimates of the total area of arable land in Iceland and Northern-Norway were obtained.

5 Examples of arable land mapping in Iceland and N-Norway

5.1 Iceland

Mapping of arable land in Iceland has previously been performed on two different geographical scales: 1) On the country as a whole (Traustason and Gísladóttir, 2009; Snæbjörnsson et al., 2010; Sveinsson and Hermannsson, 2010) and 2) individual municipalities in Iceland (Steinsholt, 2012; Gudmundsdottir, 2014; Steinsholt, 2016). These estimations were preformed using slightly different definitions of arable land and different sources of geographical data.

5.1.1 Estimation of arable land in Iceland as a whole

Several attempts have been made to estimate the total arable land in Iceland. The first published estimate of the size of arable land in Iceland was 15,000 km^2, roughly 15% of the total land area of Iceland, which is based on estimates from the National Land Survey of Iceland from 1961 (see Snæbjörnsson et al., 2010). Jóhannesson (1960) classified the soil according to agricultural requirements on the scale 1:500,000 assuming 0.15 m depth of soil but neither the variability nor continuity was known. This number is highly inaccurate, but has been widely used and cited (e.g. see The Farmers Association of Iceland 2009). More recent studies have been performed using the Icelandic Farmland Database, Nytjaland (Gísladóttir et al., 2014). Using the Nytjaland, Traustason and Gísladóttir (2009) estimated the total area of cultivable land to be around 6,150 km^2, based on similar definition as described in section 4.1, except that they did not account for soil depth. A more recent study concluded that the total area of arable land in Iceland is closer to 3,000 km^2 (Sveinsson and Hermannsson, 2010). The latter study used existing maps of hayfields and other land already in cultivation and employed local agricultural advisors, in the main

agricultural areas of Iceland, to estimate arable land not in use. The discrepancy in these two estimates simply reflect the different methodologies used. It furthermore shows that further work needs to be done on this matter in Iceland.

5.1.2 Estimates of arable land in Icelandic municipalities

In addition to the estimates of the total cultivatable land area in Iceland (see section above), studies have been done on three municipalities in Iceland, in order to determine their availability of arable land. These municipalities are: Rangárþing eystra (Steinsholt, 2012), Kjósarhreppur (Gudmundsdottir, 2014) and Hrunamannahreppur (Steinsholt, 2016). They are all located on the southern part of Iceland and their economies are highly dependent on agriculture. These studies used the same, or very similar, definition of arable land, described in section 4.1. However, their source of geographical data varied considerably. Studies conducted by Steinsholt (2012; 2014) relied on a wide variety of data sources, such as aerial photographs, the Icelandic farmland database (Gísladóttir et al., 2014) and information from local farmers. The study of Hrunamannahreppur (Steinsholt, 2016) also included weather criteria and set a minimum number of day degrees (D°) for different categories of arable land. Only areas with at least 1,250 D° over the growth period were considered suitable for cereal cultivation. The study of Kjósarhreppur relied mostly on remote sensing techniques, for estimating area of arable land. However, several on-site measurements were performed in order to verify the results (Gudmundsdottir, 2014). These studies all concluded that there are considerable amounts of unused agricultural land in these municipalities.

5.2 Northern-Norway

The area of arable land has previously been estimated in the three counties that make up N-Norway: Nordland, Troms and Finnmark (Table 1). The total area of arable land in that region was estimated to be around 900 km^2, which is roughly 0.01% of the total land area (http://kilden.nibio.no). Nordland has by far the most arable land, about 530 km^2, which is more than twice the size of arable land in Troms, 260 km^2. Finnmark, the northernmost county in Norway, only has about 103 km^2 of arable land. These estimates of arable land

were made by the Norwegian Institute of Bioeconomy Research (NIBIO), formerly Norwegian Forest and Landscape Institute. The estimates are based on vegetation mapping of the whole country in 1960-1990, which was later transferred into AR5 classification system and was fully established in 2008 (Ahlstrøm et al., 2014). AR5 is a national land capability classification system and map datasets that describes land resources in the whole of Norway on a scale of 1:5000 m, especially for capability of agriculture and natural plant production. The minimum mapping unit is 0.2 ha. After the AR5 was established for the whole country, it is updated every year by digital flight and satellite photos in addition to occasional vegetation mapping and registration. The classification of climatic zones, described in section 4.1.2 (see Table 2) does not include local climatic variation or precipitation during harvest in autumn. Based on this classification, NIBIOs database has indicated the amount of cultivated land within each agroclimatic zone (Svengård-Stokke, 2015) (Fig. 1). Areas within Northern-Norway are defined in agroclimatic zones between 4-6 (see Figure 1). For future estimates of suitable area for cereal cultivation in N-Norway, updates on agroclimatic data are needed, in addition to soil data which is only partly available for N-Norway.

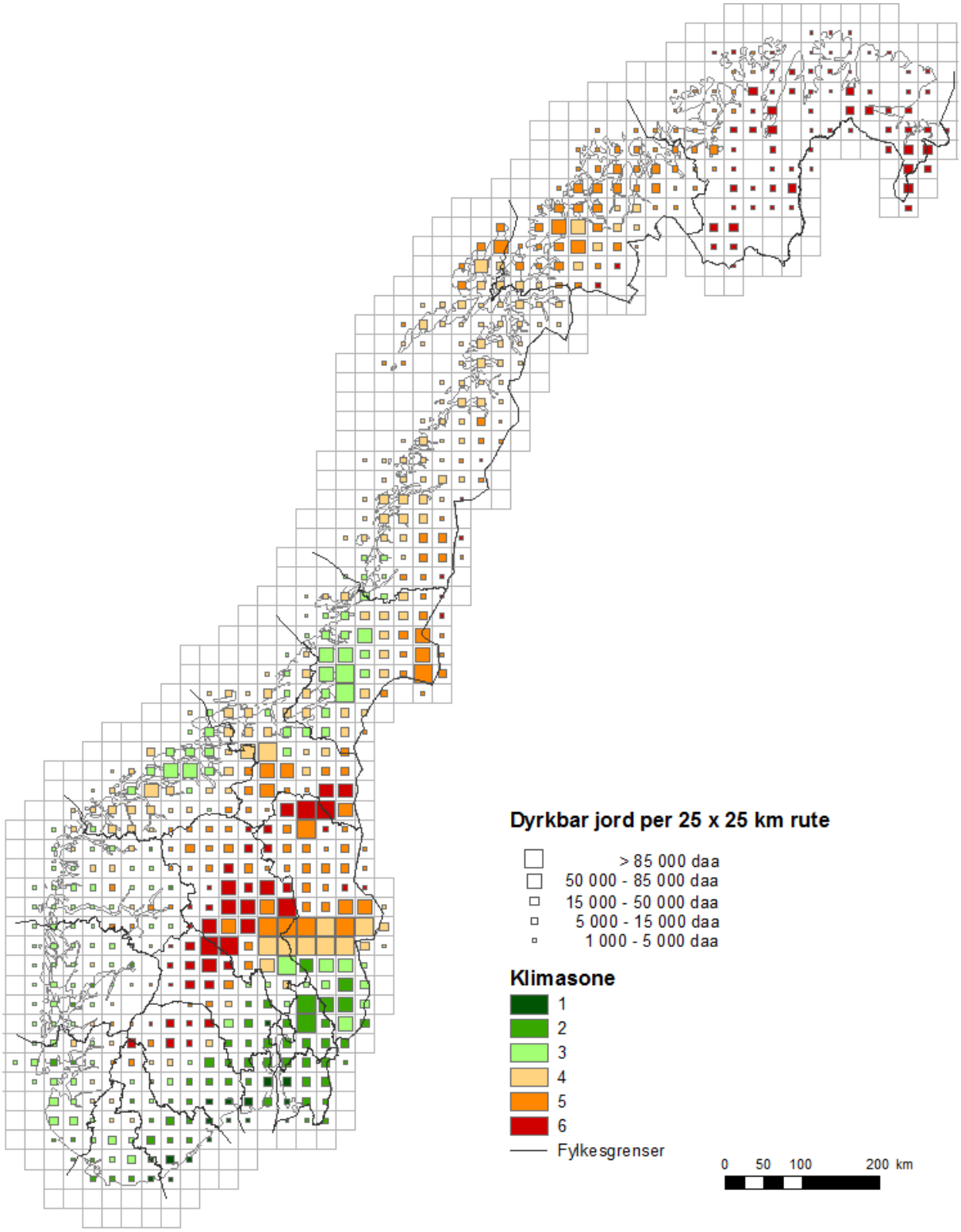

Figure 1. A map of arable land within each agroclimatic zone in Norway from Svengård-Stokke (2015). See Table 2 for information regarding each climate zone.

6 Conclusions

The estimation of arable land plays an important part in the Northern Cereal project, since it is crucial to know how much cultivatable land is available if cereal production is to be increased in the Northern Periphery region. We provided examples on how these estimates have been performed in Iceland and Norway, relatively recently. The experience gained in these two countries will undoubtedly be very valuable for estimating arable land in other regions of the Northern Periphery Region.

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