DENMARK

Source: esri

General

Denmark - officially the Kingdom of Denmark - is a Nordic country and the southernmost of the Scandinavian nations. Denmark is south-west of Sweden, south of Norway and bordered in the South by Germany. The Kingdom of Denmark also comprises two autonomous constituent countries in the North Atlantic Ocean: the Faroe Islands and Greenland. Denmark proper consists of a peninsula, Jutland and an archipelago of 443 islands, with the largest being Zealand, Funen and the North Jutlandic Island. The country has an area of 2.21 Mha (million hectares) with, in 2022, a population of 5.9 million, or 2.7 persons per ha (Wikipedia and United Nations, 2022).

Climate and geography

Denmark has a temperate climate, characterised by mild winters, with mean temperatures in January of 1.5 °C, and cool summers, with a mean temperature in August of 17.2 °C. Denmark receives on average 765 mm precipitation per year, autumn is the wettest season and spring the driest. The position between a continent and an ocean means that weather often changes (source: Wikipedia).

Denmark is a lowland area that lies, on average, not higher than 30 m+MSL (mean sea level). The country's highest point, reaching 173 m, is Yding Forest Hill in East-central Jutland. The islands are characterised by flat, arable land and sandy coasts, and a low elevation. The longest river in Denmark is the Gudenå. It flows over a length of is 158 km from the source just northwest of Tørring through the Silkeborg Lakes, northeast to the Randers Fjord on the east coast. There are many small lakes; the largest is Arresø in Zealand. Large lagoons have formed behind the coastal dunes in the West, such as at the Ringkøbing and Nissum fjords (source: Britannica).

Stenak (2005) describes that in the marshes of North Schleswig the first permanent dikes and sluices have been built since the 16th century. He also describes that the first polder drained with a Dutch windmill was recorded in 1690 when count Knut Thott at Cavnø Castle reclaimed Nylandsmosen, a shallow inlet of 138 ha. Lowland reclamation slowly began in 1750. The pioneers were large landowners trying to increase the dairy production by gaining more meadowland. Small shallow lakes and inlets were drained and endiked with primitive technical means. Excess water was discharged naturally by deepening outlets and rivers or controlled by sluices. Windmills were still uncommon. Bad drainage conditions usually resulted in the creation of poor wet grasslands. Interpretations of the Northern Funen cases do not suggest any substantial differences in drainage conditions between sluice polders and mill polders. A large number of reclamation schemes have been carried out between 1850 and 1900 (Stenak, 2005).

Stenak (2005) presents Figures with the sluice polders and mill polders around 1850 and, in addition, with steam engines around 1900 (Figures 1(a) and 1(b)).

In line with this the Group Polder Development (1982) describes that the first polders were constructed in the 16th century, but that the main period of polder development was in the 19th century. They identified 19 existing polders, with a total area of about 50,000 ha.

Stenak (2005) also gives a classification of lowland reclamation in Denmark (Table I). In Figures 2 and 3 the reclaimed lowlands are shown. However, it is described that of the four categories of reclaimed lowlands generally only the endiked tidal marshes (38,000 ha), coastal embankments (45,000 ha) and the drained lakes (17,000 ha) (in total about 100,000 ha) are real polders, and the other lowlands – meadows, fens and bogs – are only drained and not really closed off from the surrounding area. Finally he refers to a devastating flooding of the islands Lolland and Falster on November 13, 1872 when 18,000 ha was flooded.

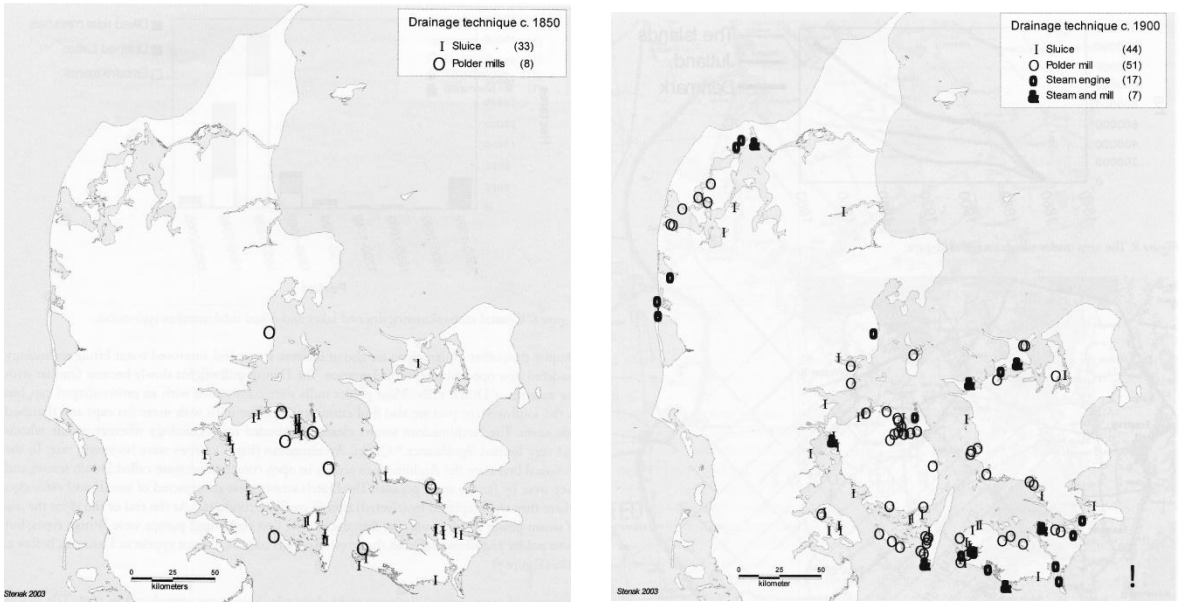

Figure 1. Drainage techniques applied in the coastal polders around 1850 (a) and around 1900 (b) (Stenak, 2005)

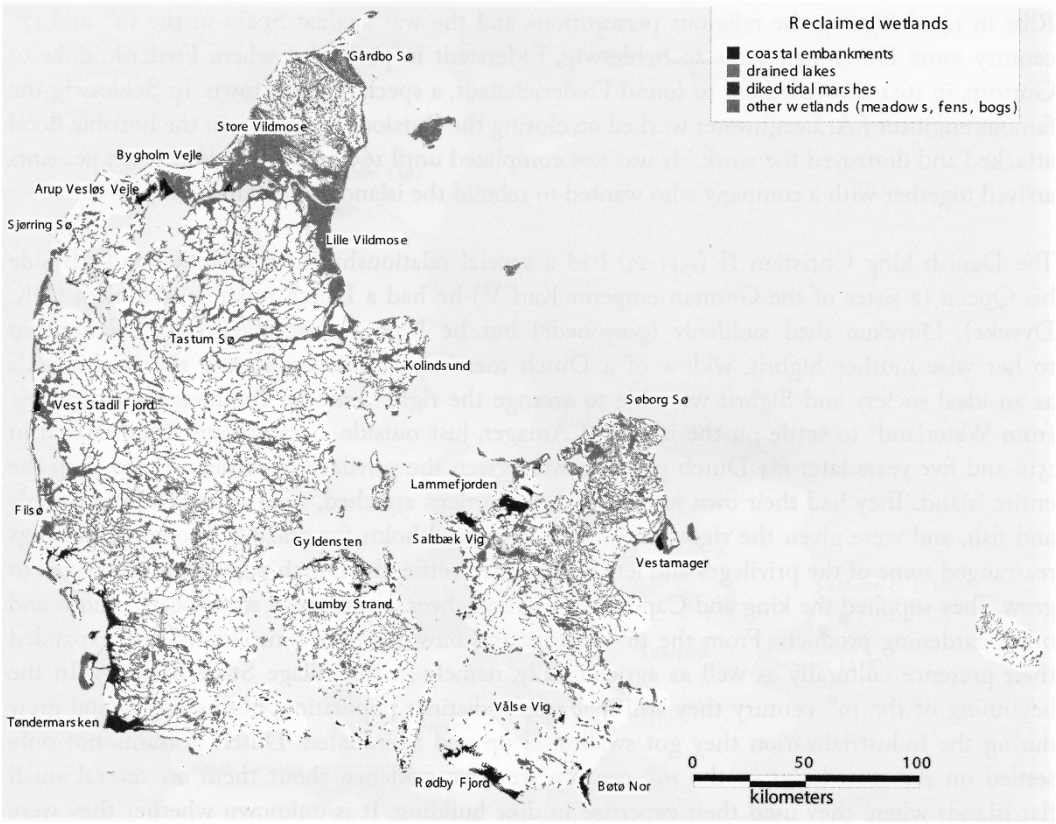

Figure 2. Reclaimed lowlands in Denmark (Stenak, 2005)

Existing polders

Stenak (2005) gives a quite detailed description of the reclamation of the Lammefjord Polder. He and the Group Polder Development (1982) describe that the Lammefjord Polder near Copenhagen, with its surface at 7.10 m-MSL, is probably the lowest polder in the world (Figure 4). This is not the case. However, it is most probably the lowest in Europe.

Figure 5 shows the drained areas with pumping stations and land reclamation areas around Ringkoebing Fjord (Grooss and Bisgaard, 2007).

Table I. Classification of lowland reclamation in Denmark (Stenak, 2005)

	Inland			Coast		
Reclamation type	River and stream regulation	Drainage	Drained lakes	Foreland making	Diking	Embankment
Natural biotopes	Rivers, streams, creeks	Meadows, fens, bogs (peat domes)	Lakes (fresh and brackish)	Foreland, marshes, estuaries	Salt marshes, other coastal lowlands	Inlets, coves, bays
Water engineering features	Outlet	Outlet, drainage	Outlet, drainage, pumping (protection)	Land reclamation fields, *grøbling*	Outlet drainage protection	Outlet, drainage, protection, pumping
Soils	Alluvial, sand, clay (peat)	Peat, alluvial sand, clay	Eutrophic mud (shells)	Clay, silt, (fine) sand	Clay, silt, (fine) sand, organic material	(fine) sand, mud, (clay/silt), shells
Water levels	Temporary or permanent water-bearing	High groundwater table	Permanent water cover	Tidal movement > 1 m	Land above mean sea level (> 0 m)	Land below mean sea level (< 0 M)
Period	1750-1970	1750-1970	1750-1970	1900-2000	1500-1980	1750-1970
Reclaimed area	60,000 km 90-95% of all rivers	510,000 ha	17,000 ha		185,000 ha (Wadden Sea 35,000 ha)	45,000 ha
Agrarian settlement	-	Farms, houses (colonies)	Farms, houses (colonies)		Farms, houses (on mounds)	Farms, houses (colonies)

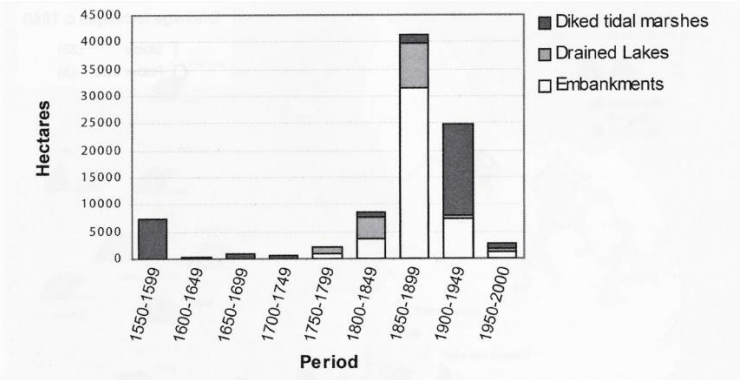

Figure 3. Drained tidal marshes, drained lakes and coastal polders (Stenak, 2005)

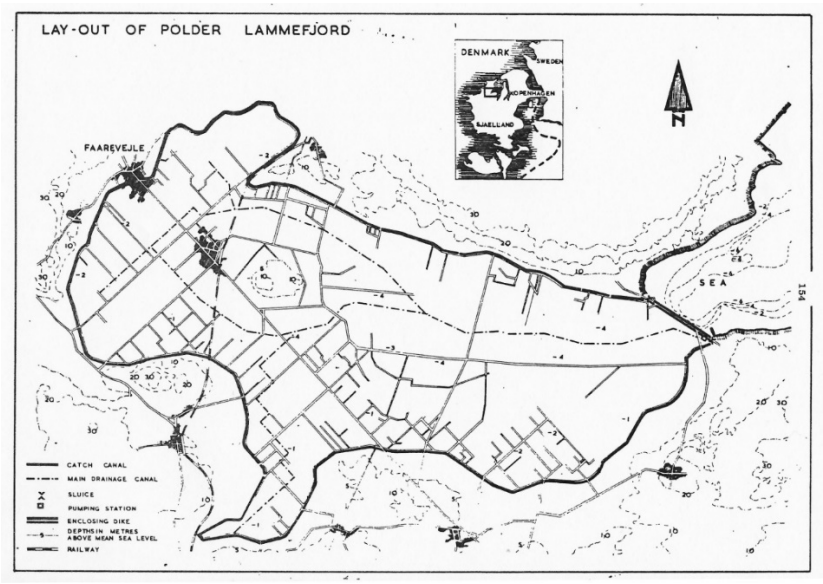

Figure 4. Lay out of the Lammefjord Polder (Group Polder Development, 1982)

Figure 5. Drained areas with pumping stations and land reclamation areas around Ringkoebing Fjord (Grooss and Bisgaard, 2007)

General characteristics of the polders in Denmark are shown in Table II. Table III shows the characteristics of the water management and flood protection systems of the existing polders.

Proposed polders

No proposed polders have been identified.

Location of the polders in Denmark as shown on the World polder map

The location of the polders in Denmark is shown in Figure 6.

Figure 6. Location of the polders in Denmark (source: esri – Batavialand)

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United Nations, Department of Economic and Social Affairs, Population Division. 2022. *World Population Prospects, medium prognosis. The 2022 revision*. New York, USA.

Web site:

- Pumping station of the Lammefjord Polder: https://audebopumpestation.dk.

Bart Schultz

Lelystad, November 2023

Table II. General characteristics of existing polders in Denmark

Name	Reclamation	Area in ha	Type *)	Latitudes	Longitudes	Elevation in m+MSL	Land use
Tøndermarsken (inner polders)	1553-1556	7.000	RLL	54º 56' N	8º 53' E	-1	Rural area
Ammager	About 1600		LGS	55º 37' N	12º 33' E	0	Rural area
Nylandsmosen	1690	138	LGS	55º 10' N	11º 45' E	-3	Agriculture
Gammel Frederikskog	1692	641	LGS	54º 55' N	8º 42' E	-1	Agriculture
Rudbøl Kog	1715	570	LGS	54º 55' N	8º 42' E	-2	Agriculture
Trekroner	1787	2					
Vitsø Nor	1788	225	LGS	54º 55' N	10º 16' E	-3	Nature
Damhus Sø	1849	46	RLL	55º 41' N	12º 28' E	6	Park
Ny Frederikskog	1861	863	LGS	54º 56' N	8º 42' E	2	Agriculture
Saltbæk Vig	1866	1,610	LGS	55º 43' N	11º 11' E	0	Lake, pumping stopped in 1921
Lammefjord Polder	1873-1875	5,764	LGS	55º 77' N	11º 5' E	-7.10	Agriculture
Kolindsund	1877	2,533	DL	56º 24' N	10º 46' E	0	Agriculture
Lumby Strand	1942	46,500	DL	55º 28' N	10º 21' E	1	Agriculture
Margrethe Kog (polder)	1981	1,151	LGS	54º 56' N	8º 40' E	0	Agriculture
Arub Vesløs Vejle			LGS	57º 1' N	8º 56' E	1	Agriculture and nature
Bigholm Vejle			LGS	57º 3' N	9º 6' E	1	Agriculture
Bøtø Nor			RLL	54º 39' N	11º 56' E	-1	Agriculture
Filsø			RLL	55º 41' N	8º 12' E	0	Agriculture
Gardbo Sø			DL	57º 34' N	10º 20' E	2	Agriculture
Gråstennor Polder			LGS	54º 51' N	10º 28' E	-1	Agriculture
Gyldensten			LGS	55º 34' N	10º 9' E	0	Agriculture
Lille Vildmose			RLL	56º 53' N	10º 11' E	4	Agriculture and water
Mogeltonder Polder			LGS	54º 55' N	8º 47' E	-2	Agriculture
Polders around Ringkøbing Fjord			LGS	56º 0' N	8º 20' E	0	Agriculture
Rødby Fjord			LGS	54º 43' N	11º 17' E	0	Agriculture
Sjørring Sø			RLL	56º 57' N	8º 32' E	6	Agriculture
Søborg Sø			RLL	56º 4' N	12º 19' E	-1	Agriculture
Store Vildmose			RLL	57º 12' N	9º 48' E	6	Agriculture
Tatsum Sø			RLL	56º 32' N	9º 5' E	3	Agriculture
Tøndermarsken			RLL	54º 56' N	8º 52' E	-1	Agriculture
Valse Vig			RLL	54º 55' N	11º 47' E	-1	Agriculture
Vest Stadil Fjord			RLL	56º 11' N	8º 11' E	-1	Agriculture
Vest Amager			RLL	55º 38' N	12º 3' E	0	Urban

Reclaimed tidal marshes		38,000					
Coastal embankments		45,000					
Drained lakes		63,500					
Total		146,500					

*) RLL = reclaimed low-lying land; LGS = land gained on the sea; DL = drained lake

Table III. Characteristics of the water management and flood protection system of polders in Denmark

Name	Design criteria in chance of occurrence/year							
	Water management						Flood protection	
	Drainage					Irrigation	Rural	Urban
	Type	Design criterion	Percentage of open water	Discharge capacity				
				m^3/s	mm/day			
Lammefjord Polder	LGS			5	7.5			
General for Denmark		Subsurface drains: • mineral soils: * depth 1.0-1.2 m * spacing 10-40 m • organic soils: * depth 1.0-1.2 m * spacing 10-40 m			8.6			