Greenland irrigation systems on a West Nordic background

An overview of the evidence of irrigation systems in Norse Greenland c. 980–1450 AD

Überblick über die Bewässerungssysteme im norwegischen Grönland (ca. 980–1450 n. Ch.)

Vue d'ensemble des systèmes d'irrigation dans le Groenland, c. 980–1450

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Introduction

About 1000 years ago according to written sources settlers from Iceland established a pasture farming community in the sub arctic parts of Southwest Greenland. The settlers were descendants of Scandinavian Vikings, and during the favourable climatic conditions of the Medieval Warm period the settlers founded the Eastern Settlement in Southwest Greenland, and the Western Settlement some 500 kilometres further to the north. The Norse settlement in Greenland lasted for about 500 years. Before 1500 AD the two settlement areas lay deserted for reasons not yet fully understood (*fig. 1*).

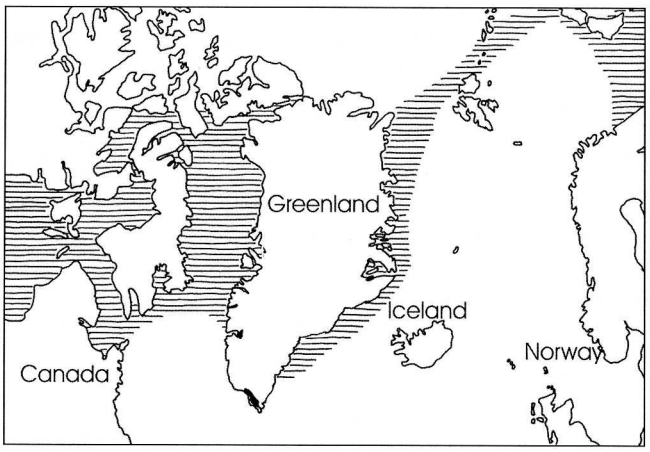

Fig. 1. *Greenland and the North Atlantic.*

Though the Norse Greenlanders subsisted partly on sheep, goat and cattle breeding and partly on fishing and hunting sea mammals both socially and economically they were heavily dependent on their land, and finds of irrigation canals in the infield or home field and dams in the mountains show that artificial irrigation was one of the strategies to secure the necessary yields. The question is whether irrigation was an integrated part of the pasture farming economy that the Icelandic settlers brought with them or whether it was introduced later to meet the environmental and/or man-made changes that took place during the settlement period.

Southwest Greenland – the natural setting

The Norse Eastern Settlement area is located at 60–61 ° N latitude, and the Western Settlement is located at 64 ° N latitude (*fig. 2*).

Long and deep fjords with intervening mountains characterize both settlement regions. Close to the outer coast the mountains rise steeply from the sea but when you enter the inner part of the fjords the landscape

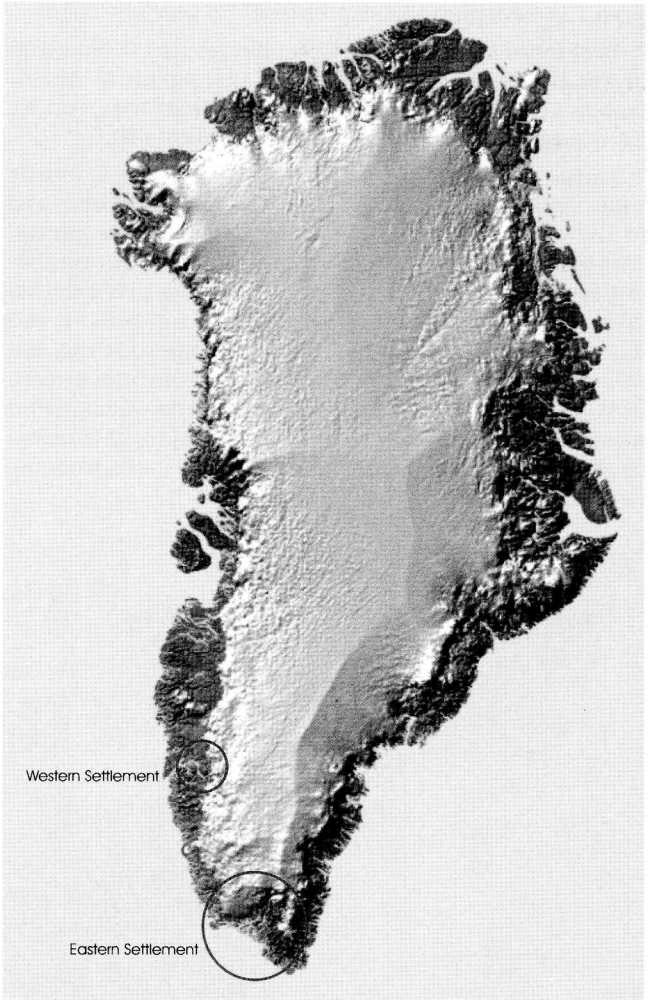

Fig. 2. *The Norse Eastern Settlement was situated in the southern part of the Greenland west coast. The Norse Western Settlement was situated in the area of nowadays Nuuk, the capital of Greenland.*

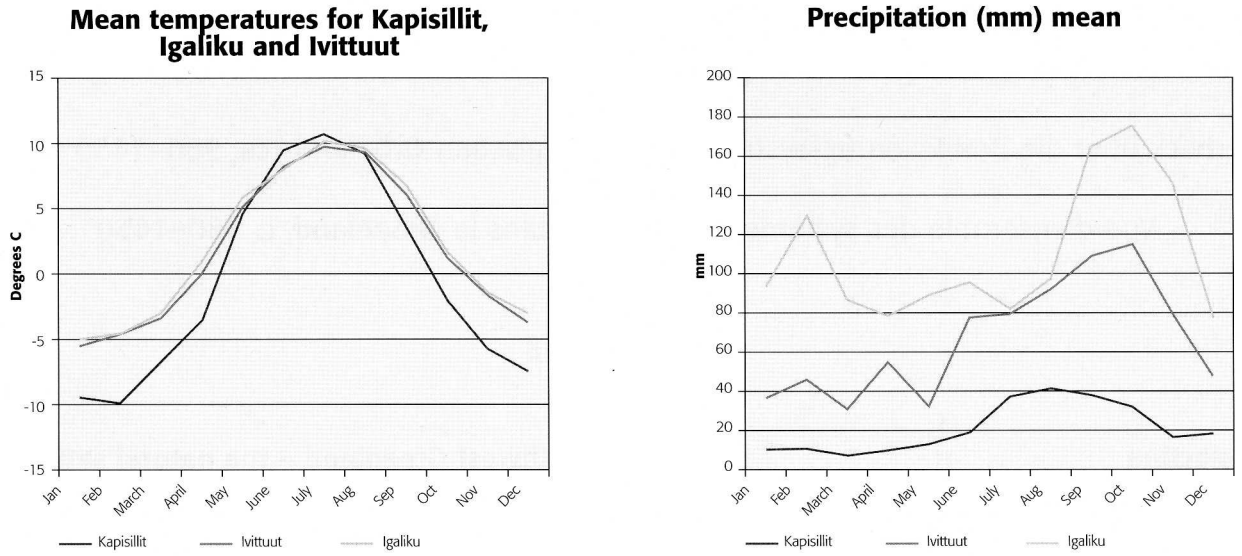

Fig. 3. *Mean temperatures and precipitation in the period 1958–1999 for Kapisillit in the central part of the Norse Western Settlement and for Igaliku and Ivittuut in the central and northern part respectively of the Eastern Settlement.*

opens up. Along the fjords are moraine plains with rich vegetation and at the head of the fjords are large luxuriant plains and valleys through which the melt water from the Greenland Icecap enters the fjords.

In general the climate of Greenland is arctic. However, in the two Norse settlement areas the climate is described as sub arctic indicating that the mean temperature for the warmest month of the year reaches +10 °C.

In the inner part of the fjords the climate is mostly continental, with relatively little precipitation compared to the outer coast. Annual precipitation in the central part of the Eastern Settlement is about 615 mm compared to about 858 mm on the coast. Most precipitation falls as rain, but snow covers the ground up to about 160 days a year. On average the mean wind speed is low, but when low pressures become stationary south of Greenland periods with very strong, relatively warm foehn winds will emerge and warm winds of gale and hurricane scale will descend upon the valleys and fjords from the Greenland Icecap.

The Icelandic colonists settled in Greenland at the peak of the Medieval Warm Period, and the climate at the time of the arrival is thought to have been warmer than the climate of today. The Medieval Warm Period is normally suggested to have lasted from c. AD 900 to c. AD 1350, when The Little Ice Age followed it (*fig. 3*).

The Norse settlements – settlement pattern & economy

Some 500 self-supporting farm units have been recorded archaeologically in the Eastern Settlement, and about 100 in the Western Settlement. In most cases the time of the life span of the individual farm is unknown.

The scattered settlement pattern reflects the pastoral farming economy the settlers brought with them from Iceland. Subsistence at the farms depended on partly the animal husbandry, partly on fishing and seal hunting (*fig. 4, 5*).

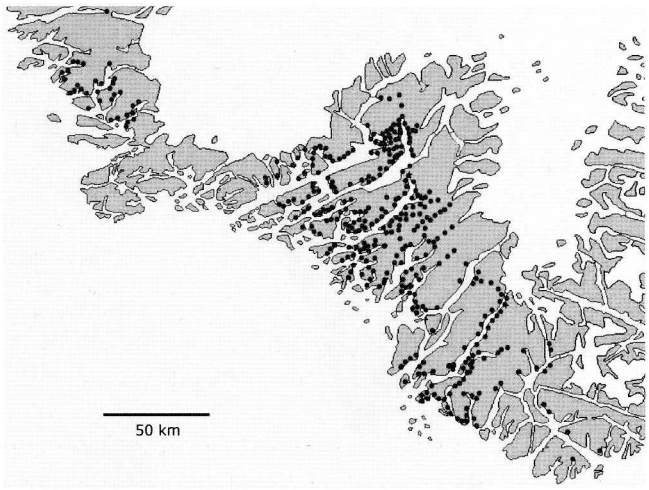

Fig. 4. *About 500 farms have been recorded in the Eastern Settlement. The farms are scattered along the fjords and in the valleys.*

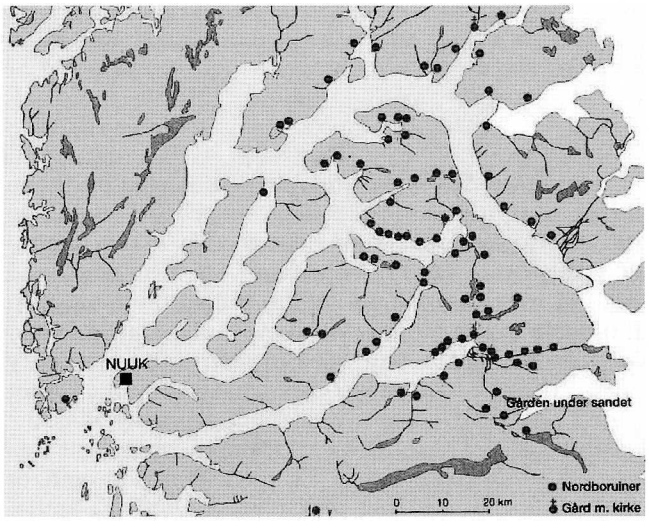

Fig. 5. *About 100 farms have been recorded in the Western Settlement.*

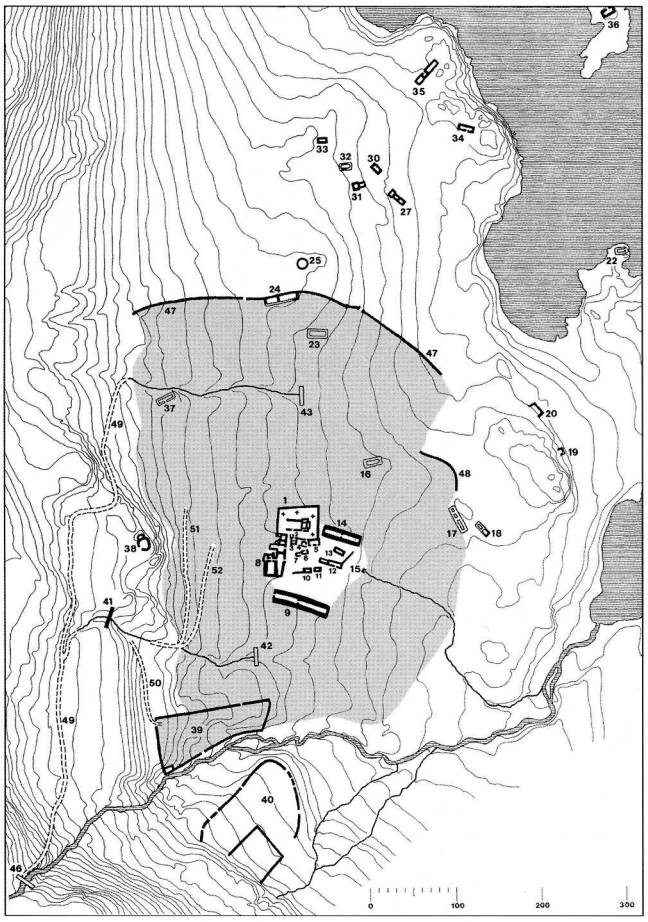

Fig. 6. *The Norse farm Gaðar where the Greenland bishops lived. After Krogh 1982.*

The Norse Greenland farms can be roughly classified in three groups: High-status or elite farms, middle-sized farms and small farms. The high-status farms consist of a larger number of houses and have a church connected. The middle-sized farms can have as many houses as the high-status farm but are without a church. The small farms consist of few houses only.

The land was used in an infield – outfield system. The infield or home field was concentrated around the farm buildings. At some farms a fence to protect the grass from straying animals surrounded the home field. In late summer – early autumn the grass on the home field was cut and stored for the winter. Cows were stalled during the winter. Sheep and goats can be out wintered with little or no supplementary fodder in Greenland to day as can horses, we do however not know the strategy of the Norse Greenland farmers (*Mainland 2000*). The number of animals in the byres and stables the farmers could keep through the long winter depended on the amount of stored winter fodder. Alternative forage such as for instance seaweed has not been recognized in the archaeological record.

Fig. 7. *Ruin in Igaliku. Photo J. Arneborg 2000.*

Irrigation systems in the Norse Settlements in Greenland

Dikes or systems of dikes of varying lengths in the vicinity of the farm buildings at several sites have been recorded archaeologically and have been interpreted as the remains of man made systems for artificial irrigation. In present day Igaliku man made dams have been recorded in the nearby mountains (A list of the farms in question can be found in *appendix 1*).

The Norse name of the farm in Igaliku was *Garðar*. *Garðar* was by far the richest farm in the Eastern Settlement. In periods the Greenland bishop lived here (*fig. 6, 7*).

To the south and to the west the river and the mountain bounded the home field of the farm. On the other sides of the home field were stone built fences. Central in the home field were the living houses, two byre – barn complexes, different outhouses and to the north the church. The byres could hold more than 100 cows (*Nørlund 1929*, 117; *Krogh 1974*, 75). In the southwest corner of the home field was a separate fenced field. We do not know the use of the field but according the to written sources rich farmers in Greenland experimented with growing grain (*Kongespejlet 1926*, 50), and the small field may have served that purpose.

The irrigation system at *Garðar* consists of a network of dug canals that distribute water from the river to the home field (*fig. 8*).

The main canal runs along the upper ridge. From the main canal smaller canals divert into the home field crosswise the edge of the ridge down to the next terrace. One of the canals feeds water into the small separate field mentioned above. In the mountain comprehensive dams were built at strategic places to accumulate the spring waters in reservoirs.

The dams were built of cut turfs that were shielded from the water in the reservoir by a heavy stonewall. The necessary openings in the dams were blocked with turf. The reservoirs served two purposes. It was easier to control the water in the canal system, which was important considering the risks of erosion and destroying the young plants. Secondly, one could store the water and use it when needed.

The Norwegian explorer Helge Ingstad was the first to recognize and describe the striking irrigation system in Igaliku (*Ingstad 1960*, 213f.), and perhaps his findings inspired the modern sheep farmers. In the begin-

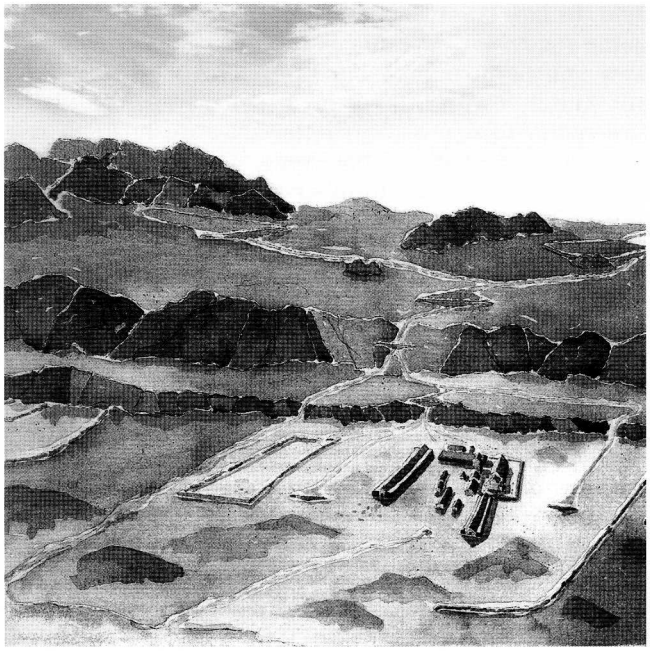

Fig. 8. *The irrigation system in Igaliku. Watercolour by Vibeke Krogh. From unpublished report in the Greenland National Museum.*

ning of the 20th century sheep farming was reintroduced in Southwest Greenland and several families made their homes in Igaliku. It was, however, difficult for the sheep farmers to gather all the hay they wanted for the winter due to the growing conditions in the area. The soil layer on the Igaliku plain is rather thin and therefore vulnerable to drought especially early in the growing season, and the strong warm foehn winds can be quite damaging.

To prevent the damages caused by the warm summer winds the sheep farmers in the 1960´ties decided to construct an irrigation system (cf. *Krogh 1974*). They built a small concrete dam across the river uphill from the home field and realised that their predecessors, the Norse farmers had had one of their dams at exactly the same spot. It was from this dam the medieval main canal had branched off. Still, the sheep farmers soon realized that the one small reservoir was insufficient to provide all the water they needed as it dried out during the summer. The Norse Greenlander may have had the same experience and that explains the comprehensive structures higher in the mountains.

After the finds in Igaliku artificially dug dikes in the home field have been recorded at several other Norse farms in the Eastern Settlement and from a single farm in the Western Settlement, and in most cases the dikes have been interpreted as irrigations canals (*fig. 9*; *App. 1*).

In Tunulliarfik fjord in the Eastern Settlement dikes of different kinds have been recorded in the region around Qassiarsuk. At the *Brattahlið* farm, another of the wealthy high-status farms in the Norse Eastern Settlement, a dike has been recorded running from the mountain behind the farmhouses down towards the home field. The dike was bordered with cut turf and *Krogh* (*1982*, 36) interprets the dike as an irrigation canal (*fig. 10*).

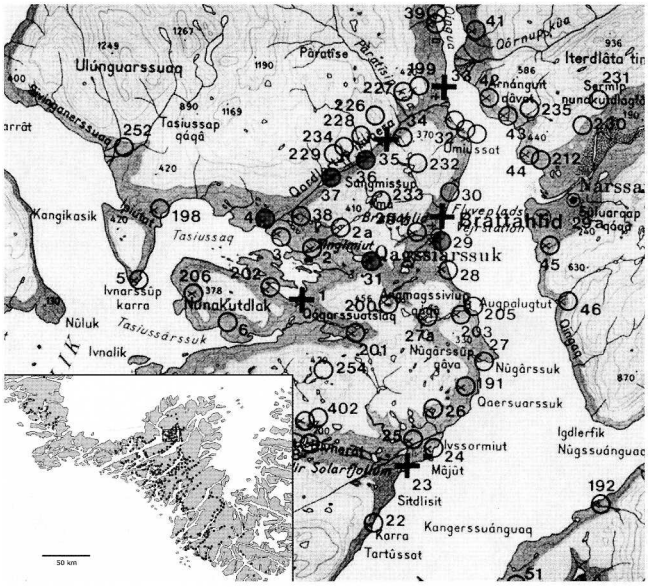

Fig. 9. *The Qassiarsuk region. Dug ditches have been recorded at the highlighted farms.*

In the fertile Qorlortoq valley just north of Qassiarsuk dikes from supposed irrigation systems has been reported at the farms Ø4 (by a Swedish research team in 1976, C. Keller pers. com.), Ø36 (Keller pers. com.) and Ø37 (*Guldager et al. 2002*, 62). All farms can be described as middle-sized and they are all situated on the north side of the river that runs in the valley. According to C. Keller, a water canal at Ø36 diverts from a mountain stream in a small canyon uphill from the farmsite, heading for the home field of the farm.

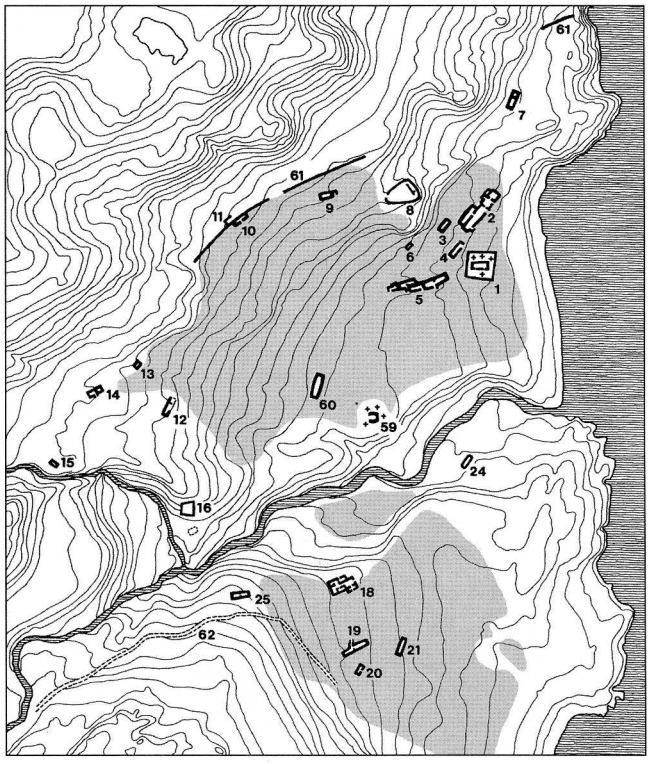

Fig. 10. *Brattahlið after Krogh 1982.*

The farm Ø37 is situated a little further up the same valley. In both Igaliku and Qassiarsuk and at Ø36 the recorded dikes run from the mountain down to the edge of the home field. From here the water could seep out into the field. In contrast, the recorded dike at the farm site Ø37 is situated in the relatively plane area next to the river. In an earlier description the same area is described as fertile grassland but swampy (*Holm 1883*, 88), and the dikes may very well have been drainage trenches.

Southwest of Qassiarsuk the farm Ø31 is situated in a grassy hollow between two lakes in the mountains. The farm is very small, only six buildings have been recorded on the site supposed to be a dwelling and five economy buildings. Some of the economy buildings have perhaps been used as sheep and goat stables. Because of the size and position in the mountain the farm may have been used seasonally only, presumably during the summer grazing season. The buildings are placed on rises and in the lower lying areas the two lakes are connected with both a natural watercourse and with artificial made dikes, that have been interpreted as irrigation ditches (*Guldager et al. 2002*, 74). As mountains surround the site the lakes and the land around them may have acted as catchment area for the melt water coming from the higher ground. Therefore, rather than artificial irrigation the site may have needed drainage (*fig. 11*).

Besides *Garðar* in Igaliku fjord dikes from supposed irrigation systems have also been recorded at the farms Ø59 (*Krogh 1974*, 79), Ø79 (*Albrethsen 1971 /1980/*), Ø172 (*Krogh undated report*) and Ø78 (*Krogh undated report*) (*App. 1*). At the middle-sized farm Ø79 a ca. 220-meter long dike is running down from the mountain onto the home field. Low banks are visible along the sides of the canal. Test trenches in the banks, however, did not give definite answers to how the dike was constructed. The position in the landscape indicates that the dike may very have been used for irrigation purposes.

Further to the south in the Uunartoq fjord the remains of a dam presumably for irrigation purposes have been recorded at the farm Ø149 which is supposed to be a nunnery (*Krogh undated report*).

In the Western Settlement dikes have been recorded at the high-status farm Sandnes at Kilaarsarfik in the Ameralik-Ameralla fjord. However, as one of the recorded dikes points to one of the byre-barn complexes the dike may as well have formed part of the water supply to the building.

Discussion

Except for the irrigation system in Igaliku the reported dikes are in most cases superficially documented, and as demonstrated above the interpratation of some of them may be questioned. Drainage trenches and canals for water supply to the living houses, byres and stables cannot be ruled out. The Norse Greenlanders were not unfamiliar with water managements of different kinds. At the *Brattahlið* farm in Qassiarsuk one of

Fig. 11. *The Igaliku region. Dug ditches have been recorded at the highlighted farms.*

the first initiatives of the settlers after their arrival was to deepen the natural outlet from a small lake behind the houses most probably to secure the water supply of the farm (*Fredskild 1969*, 51). At the early 11th century farm in Narsaq – also in the Eastern Settlement – the dwelling had a complicated indoor system of stone built canals that may have served the double function of both water supply and drainage (*Vebæk 1993*, 25).

The pastures were of vital importance to the Greenland farmers and both fertilizing with manure (*Schweger 1998*,16) and the construction of irrigation systems was a way of providing a safe harvest in years with abnormal weather, as well as a system to promote higher yields.

Despite the incomplete recording it is obvious that irrigation systems were not present at all Norse Greenland farms. *Garðar*, *Brattahlið* and farm Ø149 are considered high-status farms with *Garðar* on the absolute top, whereas the farms Ø59 and Ø79 are middle-sized. One issue already mentioned is the predominance of cattle over sheep and goats in the high-status farms (*McGovern 1985*). In comparison, cattle demands a huge amount of winter fodder due to the extensive period of indoor feeding necessary in these latitudes. The animal bone records from the farms mentioned here are admittedly scanty but the large byres at both

Garðar (*McGovern 1985*) and *Brattahlið* (*Nørlund – Stenberger 1934*, 86, 87 & 90) signal a large number of cattle, and it seems obvious to associate irrigation in Norse Greenland with primarily the farms where winter fodder were most in demand i.e. the farms with a considerable number of cattle.

Irrigation was not prerequisite for pastoral farming in Greenland but it may have been a safeguard against the warm and dry foehn winds and it may have promoted higher yields permitting the farmers to keep more animals alive through the winter and not the least, it may have provided an opportunity to keep more cattle than would otherwise be possible. Unlike cattle the sheep, goats and even horses may to a great extent have been left to themselves during the winter. The more prestigious cattle, on the other hand, had to be stalled and fed during the winter. The sizeable byres at Garðar may have been an overwhelming demonstration of wealth and power.

The use of irrigation may therefore be seen in the light of the social and economic strategy in the Norse Greenland society. As the period up to about ca. 1300 was characterised by increasingly wind activity resulting in erosion (*Jensen et al. 2003*, 61f.) and presumably also periods with drought irrigation may however have turned out to be a necessary strategy and a response to changed environmental conditions.

Irrigation systems in the Western Nordic region – a brief overview

Irrigation activities in Norse Greenland are undated but must necessarily stem from the limited period of Norse settlement in Greenland. In Iceland artificial dikes or canals have been recorded in several places (Keller pers. com. 2003) it is however doubtful whether they are from the medieval period. Especially in the middle of the 19th century irrigation of grass fields and meadows became widespread in all of the Nordic countries (*Hatt 1953*, 72f.; *Michelsen 1995*, 53) and it is likely that the majority of the mentioned dikes in Iceland may be dated to that period. Written sources however show that irrigation was used in Iceland in the medieval period (cf. *Hatt 1953*, 72).

In Norway – where the settlers in Iceland and Greenland originally came from - irrigation of both grass fields and cornfields are known from at least the late 16th century (*Kleiven 1915 /1973/*, 180–190 & 329; *Visted – Stigum 1951*, 168; *Kummen 1983*; *Michelsen 1995*, 43). Irrigation was especially used in the region around Gudbrandsdalen, where the mean yearly precipitation is only about 250–350 mm, but also at the inner fjords in the northern part of Vestlandet and to the south (in the vicinity of Oslo) the cornfields were watered artificially (*fig. 12*; *Michelsen 1995*, 42).

In the 17th century systems the water was led from the mountain through open ditches, usually diverted into wooden pipelines for the distribution of water to the individual farm, sometimes over distances of many kilometres. In order not to devastate the young plants in the beginning of the growing season and/or not to

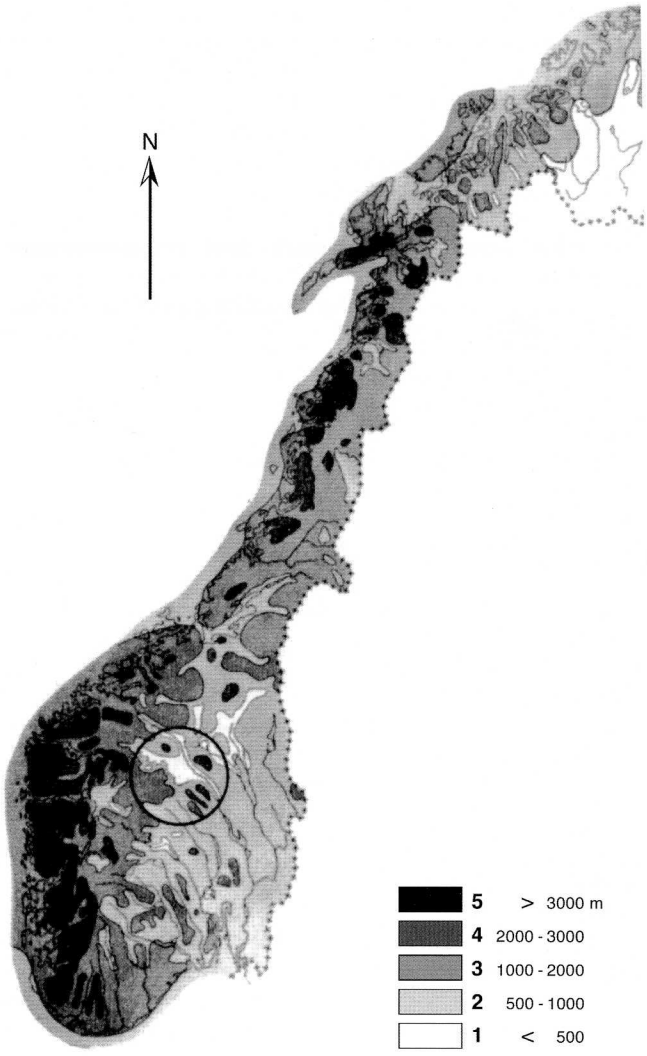

Fig. 12. *Norway. Gudbrandsdalen is in the circle. After Michelsen 1995.*

cause soil erosion in the steep fields the farmers in Gudbrandsdalen used a special technique called *skvætning*. Instead of just letting the water seep into the fields at intervals holes or reservoirs were dug in the canals and from here the water was scooped out into the field with a special shovel (*Fig. 13*; *Michelsen 1995*).

Recently at the farm Ormelid in the mountains of the Norwegian Vestlandet a more than 30-metre long subterranean canal was found pointing towards the home field of the farm. Radiocarbon dates indicate that the canal was in use from after AD 1410–1460 and that is was still in use around AD 1640. According to the excavator Janicke Åstveit the canal may have been for either drainage or irrigation. As Ormelid is situated in a region with low precipitation irrigation seems to be the most reasonable interpretation (*Åstveit 1998*, 2f., 61ff.). Also at the mountain farm or shieling site connected to Ormelid irrigation canals have been recorded. The mountain farm was in use from the Middle Ages to modern time, and the irrigation system is undated (*Åstveit 1998*, 79).

The age of irrigation in Norway has been much discussed. In the written sources we learn of irrigation

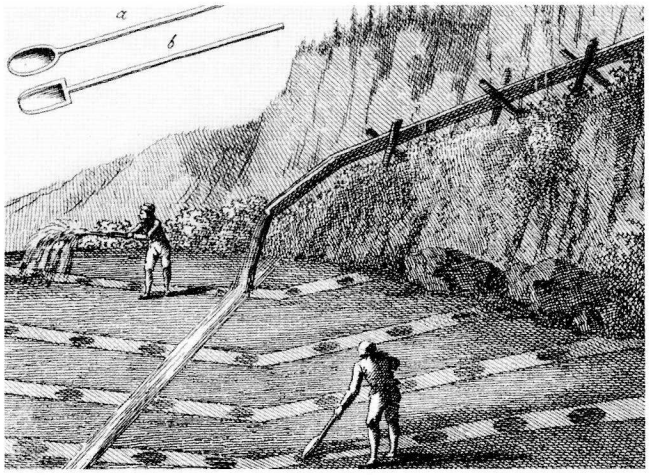

Fig. 13. *Skvaetning in Gudbrandsdalen. The illustration is from 1785. After Michelsen 1995.*

in Gudbrandsdalen from the late 16th–17th centuries (*Visted – Stigum 1951*, 168; *Michelsen 1987*, 253; *1995*, 43). These systems are, however, designed for grain production, and differ from the Norse Greenland systems in design and use. The irrigation system in the Lærdal region in the West Norwegian fjords are poorly dated, but they were designed for grass production and have many morphological features in common with the ones in Greenland. On the assumption that the Norwegian Vikings brought the technique with them from their homeland the find of the irrigation system in Igaliku in Greenland have however given rise to the theory that irrigation in Norway is older that the Norse settlements in Greenland (*Michelsen 1987*, 254).

Conclusion

In Norse Greenland water management to secure the water supply of the households was undoubtedly an integral part of the cultural packages brought by the settlers from their homelands to Greenland. Artificial irrigation may very well have formed part of that same package as an integrated element of the pastoral farming economy introduced to the new land. Apart from the irrigation system in Igaliku, the Norse bishop see *Garðar*, our recording of irrigation systems in Norse Greenland is still very incomplete. The suggestion put forward here that irrigation has to be looked upon as an integral part of especially the cattle economy of the high-status and wealthier farms in Norse Greenland may therefore be seen as a preliminary model for future research.

Acknowledgements

I want to thank Christian Keller of the University of Oslo very much for having shared with me his great knowledge of irrigation systems in Norway, Iceland and Greenland and for having commented on the manuscript of the present article. I also want to thank Trond Løken of Stavanger Museum for information on Norwegian irrigation systems and Simun Arge, Føroyar Fornminnissavn, for comments on the manuscript.

Appendix 1

The list includes all Norse farms in Greenland from where proposed irrigation canals have been recorded.

Ø4 – Ruin group Ø4 is a middle-sized farm situated in the protected Tasiusaq inlet. A well-preserved ruin of a byre as well as ruins interpreted as sheep and/or got stables show that cattle, sheep and goats were kept on the farm. A supposed water canal was recorded and trial excavated by a Swedish research team during the Nordic Archaeological Project in 1976 (Christian Keller pers com.). Unfortunately there is no report from the investigations.

Ø29a – The farm is situated in Qassiarsuk in Tunulliarfik fjord and is believed to be identical with Eric the Red's farm *Brattahlið*. The farm is a high-status farm and the centre of the area. Several byres and stables on the farm have been recorded, and even though the number of animal bones that have been collected at the farm is small, it points to a predominance of cattle compared to sheep and goats (*McGovern 1985*, 111). The farmed was inhabited from early *landnam* to depopulation. An artificial canal that takes water from the mountains to the home field has been recorded. Archaeological excavation shows that the canal was paved with cut turf (*Krogh 1982*, 36).

Ø31 – Ø31 is a very small farm situated on a grassy spot in the mountains. It may have been a mountain farm or shieling for seasonal use (*Bruun 1896*, 300ff.). Systems of dikes between two lakes at different levels have been recorded at the farm (*Guldager et al. 2002*, 74).

Ø36 – Ø36 is a middle-sized farm situated almost in the middle of the Qorlortoq valley (*Holm 1883*, 87). Supposed irrigation canals in the home field have been recorded during the Nordic Archaeological Project in 1976 (Christian Keller pers com.). Unfortunately there is no report from the investigations.

Ø37 – Ø37 too is situated on the Qorlortoq valley. It is a middle-sized farm. *Guldager et al.* (*2002*, 62) reported supposed irrigation canals in the home field in 1999.

Ø47 – Ø47 is situated on the coast in Igaliku fjord. It is the largest farm in the Norse Greenland settlements, and the bishop resided here from c. 1124 to 1378. Two large byre-barn complexes at the farm have been archaeological investigated. Put together the barns could house about 100 cows (*Krogh 1974*). Recorded at the site is a presumably complete irrigation system with canals running from the mountain down to the edge of the home field. In the mountain barrages and reservoirs have been recorded (*Krogh 1974*).

Ø59 – According to *K. Krogh* (*1974*, 78) uniquely preserved irrigation canals have been found at the midde-sized or large farm in Igaliku fjord. No report on the recording is available.

Ø78a – Farm Ø78a is situated on the coast in Igaliku fjord. It was a small farm with sheep and/or goats

as the economic basis (*Vebæk 1943*, 7ff.). According to a report by Knud Krogh in the archives of The National Museum in Copenhagen irrigation canals were reported at the farm Ø78a in 1985. No further information is available.

Ø79 – Also farm Ø79 is situated in Igaliku fjord. The farm is middle-sized. The recorded dike is running from the mountain down to the edge of the home field. The dike was archaeological investigated in 1971 it was however not possible to get knowledge of the construction of the dike (*Albrethsen /1971/, 1980*, 35 & 159).

Ø149 – The farm Ø149 is a high status farm with a church connected. The economy of the farm was based on cattle (*Vebæk 1991*). According to a report in the Danish National Museum by Knud Krogh in 1981 a dam by a small river adjacent to the ruins were found. No further information is available.

Ø172 – The farm Ø172 is situated on a large plain on the coast in Igaliku fjord. It is a middle-sized farm. According to a *report* in the Danish National Museum by *Knud Krogh* a possible dike was recorded at the site in 1985. According to Krogh one can not rule out the possibility that the depression is an old track. No further information is available.

V51 – The Western Settlement farm V51 is an elite farm with a church connected. The farm is situated on a large plain at Kilaarsarfik at the head of Ameralik Fjord. The farm has been identified with the Norse farm Sandnes. It had two large byres and the animal bone record shows that cattle were the economic basis of the farm. Several dikes in the home field were recorded in 1984 during the archaeological excavations that took place that year (*McGovern et al. 1996*).

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