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Research Article

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Transnational cooperation to develop local barley to beer value chains

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Abstract: Transnational cooperation is a common strategy for addressing research and development (R&D) issues resulting from similar challenges that cut across administrative borders. Value chains for food and drinks are complex, and transdisciplinary work is recognised as a method for solving complex issues. The Northern Cereals project ran from 2015 to 2018, and its goal was to increase cereal production and the value of grain products in four regions in the Northern Periphery programme area. The project included both R&D, but the main emphasis was on development, and was carried out by transdisciplinary cooperation between R&D partners and small and medium-sized enterprises (SMEs). By reviewing the project's methods, outcomes and composition, we discuss if a framework of transnational and transdisciplinary cooperation can help to develop the value chain from local barley to beer. We found that transnational cooperation was achieved successfully, that stakeholder involvement was crucial, but that academic disciplines such as marketing and innovation could have been included. In addition, we recognised that much work remains to further increase cereal production and the use of local grain in the Northern Periphery region, but believe that this project has laid a good foundation for further progress.

Keywords: Northern Periphery region, transnational, transdisciplinary, value chain barley to beer

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1 Introduction

Transnational cooperation is one of the main strategies in many research and development (R&D) projects because it is recognised that many common issues can be more effectively and innovatively solved by collaboration than by isolated national initiatives (Dühr and Nadin 2007). Achieving added value is a goal for such cooperation (Colomb 2007). Food and drink value chains are complex, stretching from primary production, through processing, marketing, consumption, waste and recycling. Although food and drink value chains have become increasingly globalised, in recent decades a local food movement has arisen as a reaction to this, and “local” has frequently been associated with “sustainable and healthy production and consumption patterns” (Brunori et al. 2016). It is recognised that new ways of generating knowledge, apart from traditional academic discipline-based approaches, are needed to solve complex challenges. Transdisciplinary is recognised as a suitable method for solving complex issues, where researchers from different disciplines work together with stakeholders (Maasen and Lieven 2006) to develop knowledge that is integrated between science and society (Tress et al. 2005).

The Northern Cereals project ran from 2015 to 2018, and its aim was to increase cereal production and the value of grain and grain products in the Northern Periphery region (as defined by the Northern Periphery and Arctic Programme). The project adopted a value chain perspective and included R&D partners from four countries in the Programme area as well as a total number of 310 stakeholders. The region shares several common features such as low population density, long distances to the larger markets, challenging growing conditions and a large impact from climate change (Natcher et al. 2019). One focus was on the barley to beer value chain and here there were large national differences in the extent of its development. The project acknowledged these differences by allowing each partner to concentrate on the aspects that were considered locally most important. In all activities, there were two or more partners

collaborating, creating many opportunities for mutually beneficial exchanges of knowledge and experience.

The value chain from barley to beer in the Northern Periphery region has multiple challenges. One of the most basic, however, is the barley production in which the lack of knowledge, experienced producers, machinery and equipment, as well as locally adapted barley varieties, are limiting the expansion of the crop. However, market trends favouring local or high-provenance products, more plant-based food and sustainable production are making northern food and drink products more attractive to consumers (Martin et al. 2016a). One significant result of this has been an expansion in microbreweries in remote regions where they can benefit from a unique locational identity (Withers 2017). Microbreweries usually have an important positive effect on the local economy and tourism (O'Connor 2018), and as product differentiation and provenance are important, some microbreweries have a particular interest in using local cereals (Danson et al. 2015) as a means of linking their products to a locality and heritage.

The development of the complete value chain requires access to a wide range of knowledge and skills. Knowledge from various disciplines such as agronomy, plant physiology, chemistry, food science, innovation, marketing and economics must align to achieve success. In addition, when concrete results such as increased barley production, improved drying, improved malt quality and higher value beer products are sought, it is necessary to work closely with the practitioners. Therefore, the project used a transdisciplinary approach where challenges were addressed in close cooperation with associate partners and other stakeholders.

The research question of this article is as follows: Can a framework of transnational and transdisciplinary cooperation promote development in local barley to beer value chains? Empirically, the study focuses on work carried out in the Northern Cereals project in the Northern Periphery region. A summary of the methods utilised, outcomes, and partners and stakeholders involved in the project is presented to evaluate the cooperation and transdisciplinary effects. The study concludes with suggestions, both for further development of this value chain and for transnational cooperation.

2 Transnational and transdisciplinary cooperation in R&D

The Northern Cereals Project was funded by the EU's Northern Periphery and Arctic Programme in which both

transnational and transdisciplinary cooperation are key driving forces. The programme emphasises the use of the individual strengths of the partners, and transnational cooperation facilitates a joint approach for tackling common issues. According to Pisani and Burighel (2014), transnational cooperation projects create an opportunity “to exchange fruitful information, contextual expertise and local knowledge, thus enhancing the opportunities for innovation and economic benefits”. Ray (2001) explained the rationale behind the benefits stemming from transnational cooperation as “to take advantage of similarity”, “to take advantage of complementarity” and “to reach critical mass”. However, it has also been recognised that successful (policy) transfer depends on the nature and quality of the cooperation (Colomb 2007). Cooperation in the Northern Periphery region aiming to improve the barley to beer value chain is well suited to this rationale. Similarities between the areas include geography, climatic conditions and cultural background, which make cooperation easy as participants feel a natural connectivity. In addition, using each participant's strengths improves the result and, in a region that is sparsely populated, there are considerable advantages in linking together SMEs from the whole region through knowledge exchange and networking activities. Such cooperation is not easy, however, and although transnational collaboration is expanding, good examples of working across administrative borders are exceptions (Dühr and Nadin 2007).

The academic division into narrow disciplines has fostered specialisation into increasingly more focused areas. Many of today's complex issues, such as climate change, food security or poverty reduction, cannot be resolved within single discipline. As a reaction to this, transdisciplinary methodologies have been proposed as a solution, where researchers from different disciplines work together towards a common goal where theory and knowledge between the various disciplines are integrated, and where non-academic participants are included in the work (Tress et al. 2005). Scholz and Steiner (2015) conceived transdisciplinarity as a mutual learning process between science and society to attain knowledge about a specific real-world issue. Moreover, it facilitates bringing societal concerns into scientific research (Maasen et al. 2006). This type of R&D must be contextualised to the specific study area, and the aim of the outcome is to produce “socially robust knowledge”.

According to Nowotny (2003), such “robustness” is more likely to be achieved through the involvement of a heterogeneous group of “experts”. Stakeholder involvement is a crucial part of transdisciplinary research and ensures that “the ‘right problem’ gets addressed in

“the right way” (Maasen and Lieven 2006). Triste *et al.* (2014) also included increased learning opportunities as an advantage stemming from stakeholder involvement, which is also considered to ensure impact, as in real life changes (Gasparatos *et al.* 2008). However, there are many definitions of what a stakeholder is. Alrøe and Noe (2016) wrote that stakeholders are “those who will bear the consequences and carry out actions for change”. Key stakeholders or primary stakeholders are also used as concepts for stakeholders more directly connected to (in this case) the value chain from barley to beer (Alrøe and Noe 2016). Tress *et al.* (2005) also emphasised that the level of stakeholder participation – the extent to which they are informed, consulted, involved or in control – determines their influence on the work. For a project, it is therefore important to define the role of the stakeholders, especially to fulfil the expectations the involved parties have about the project.

3 Methods

The objectives of the Northern Cereals project were very broad and could only be addressed by accessing knowledge and experience from many different disciplines. All the partners had some of these skills or knowledge, but no single partner had access to all of them. The project, therefore, provided a mechanism for pooling this expertise for the benefit of all partner regions. Although the project included both R&D, the emphasis was on the latter and the partners spent most of their time working with farmers and SMEs in very practical situations and under diverse “northern” conditions.

Simplified, the barley to beer value chain consists of the following four distinct parts: growing the barley, malting, brewing and marketing. All of them are connected,

and each depends on the quality of the output from earlier steps of the chain to perform well. Figure 1 shows these four parts and the various challenges along the value chain.

The activities in the Northern Cereals project were structured under work packages (WPs), coordinated by an overarching Management WP led by Matis, Iceland. Each WP was led by an individual researcher with skills that were relevant to the WP, and the WP leaders were responsible for coordinating WP activities with participating researchers in all the other countries. All researchers then liaised with stakeholders in each WP to ensure that the WP activities were implemented. Project WPs addressed the challenges identified in Figure 1 through five main areas of activity summarised in the following sections.

3.1 Test production of barley

To develop the complete value chain, it is necessary to start with well-adapted varieties of barley. This was the main task in the Northern Cereals preliminary project (Reykdal *et al.* 2016), but several trials (Table 1) were also established during the main project period, and these were also used for demonstration purposes. Data collected from trial plots included characteristics such as grain and straw yield, grain moisture at harvest, thousand grain weight, the occurrence of diseases and lodging and rainfall and temperature data over the growing season. There was a special emphasis on the identification of early maturing varieties because of the importance, throughout the region, of early harvesting. Data from the trials were analysed by the researchers responsible for them and were summarised for the other project partners. Grain from trials and demonstrations was used for other project activities, especially product development. Both in the Faroe Islands and in Northern Norway, the introduction

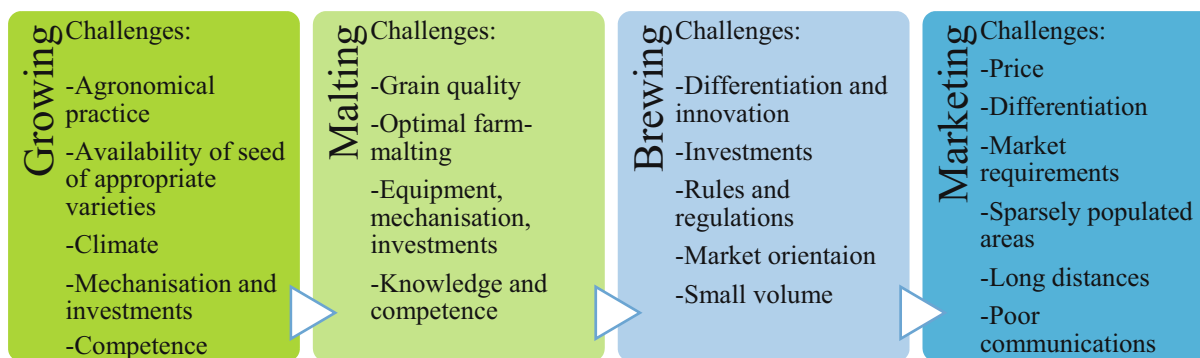


Figure 1: Challenges in each step of the value chain from barley to beer.

Table 1: Number of trials in test production of barley and small-scale malting

Country/region	NO	FO	OR	IS
Number of cereal trials/demonstration plots	8	3	5	1
Number of small-scale malting trials	4	2	3	2

FO = Faroes Islands, IS = Iceland, NO = Norway, OR = Orkney.

of appropriate machinery was also an important issue for potential cereal farmers. Guidelines and handbooks for farmers were developed in all the partner languages to aid the production of good quality grain. In the Northern Periphery region, post-harvest drying of grain is essential for safe storage, and case studies and guidelines concerning drying were developed in Iceland.

3.2 Malt quality experiments and case studies

Several small-scale malting trials (Table 1) were carried out during the project period in Scotland, Iceland and Norway, and guidelines summarising quality criteria for malting barley and case studies of floor malting methods were prepared. Two experimental malting trials were performed using test malting facilities at The Norwegian University of Life Sciences. The colour, moisture, extract, nitrogen content, friability, homogeneity and diastatic power of malt produced during the project typically were analysed. Although the brewers need to take all of these factors into account while brewing, the extract is especially important as it is a measure of the amount of sugar obtained from the malt after mashing, which is important for alcohol yield. Data from the samples malted during the project were summarised and included in reports stored on the project website which made them available to all partners.

3.3 Product development

Product development was performed by the breweries themselves, and several new products were taken to the market, including beer made from locally grown and malted barley. However, most of these products were test products or produced in limited quantities because of the shortage of local malt. The acceptability of products was assessed by the companies themselves based on in-house testing and feedback from their own client base, sometimes using social media or web-based sites.

3.4 Market knowledge

The marketing segment of the barley to beer value chain was mainly handled by the brewery stakeholders through their normal marketing channels. However, the R&D project partners also carried out a review of the market situation for barley and malt in the region. This also included global trends in the cereal food and beverage markets.

3.5 Knowledge transfer

Knowledge transfer between the project's associate partners (mostly SMEs) and the R&D partners in the different countries was the key to the project's success. Important mechanisms for doing this were the project meetings and the four conferences. They were held in four of the participating countries, with invited presenters and stakeholders, and included field trips and study visits to farms, malting facilities and breweries in addition to social activities. These facilitated the development of new networks and cooperation as well as knowledge transfer. In addition, all regions held local knowledge transfer events throughout the project period. The project also offered 4-day training placements for participants interested in starting their own malting, at a floor malting facility in Orkney, Scotland. In total, 310 stakeholders participated in the project in various ways (Table 2).

Table 2: Total number of stakeholders

Stakeholders	IS	NO	OR	FO	Total
SME	143	75	61	7	286
Business support organisations	5	10	9	0	24
Total	148	85	70	7	310

FO = Faroes Islands, IS = Iceland, NO = Norway, OR = Orkney.

4 The context – the value chain from barley to beer in the Northern Periphery area

The region shares several common features such as low population density, long distances to the larger markets,

challenging growing conditions (especially, poor soils, large variations in rainfall and temperature during the short growing season, and difficult harvesting conditions) and a large impact from climate change (principally increased temperatures in both summer and winter). Recent warming in the northern regions has helped to increase the potential for barley production (Martin *et al.* 2017), and this may help to offset the decreased agricultural production predicted in some more southern areas as a result of climate change (Muller *et al.* 2010). Nevertheless, in some years, other weather-related factors, such as high rainfall, drought, gales and late or early frosts, continue to make growing barley risky in parts of the region.

Barley has been grown in Norway and northern Scotland since ancient times, and production was introduced to both the Faroe Islands and Iceland in the ninth century. However, it is only in Orkney and Northern Norway that the cultivation has been continuous, although in Northern Norway there was a marked decline after the 1940s, due to both economic and political reasons (Halland *et al.* 2018). In Iceland, cultivation started again in 1923 and has been continuous since then with considerably increased production over the last few decades. In the Faroe Islands, barley was recently re-introduced. In Orkney, barley is an important established crop that is cultivated with a high level of mechanisation.

Barley is well-suited for the cool climates of the Northern Periphery region where the growing season is short and strong winds and frost can be expected. However, grain is often harvested at a high moisture content, which means that it needs to be dried for food uses although there is always an option to process the grain as wet feed for animals.

An important potential market for local barley is to supply malt for brewing. This results from the recent expansion of northern tourism, the increased demand for high provenance drink products and the growth of microbreweries or craft breweries. For example, in Iceland, the number of tourists has quadrupled from 4,89,000 in 2010 to 22,25,000 in 2017 (Icelandic Tourist Board 2018) and since the first independent craft brewery opened in 2006, there are now about 20 which are associated with the Independent Craft Brewers of Iceland on the organisation's Facebook page.

In peripheral northern areas, there are, however, some major constraints on using local barley to produce beer, especially the availability of grain of a suitable quality and quantity, and a lack of local facilities for using this to make malt. Grain quality issues stem mainly from a lack of

specific malting varieties adapted to northern areas. As a result, non-malting varieties tend to be used which are likely to give malt with lower extract yields than imported malt made from the recognised malting varieties. Challenging harvesting conditions may also make it difficult to obtain grain of good quality with a high germination percentage for malting. Brewing within the region is therefore mainly carried out with malt imported from a small number of very large malting companies in Germany or the United Kingdom (Nordic Innovation Centre 2009).

Most of the partner regions have considerable potential for expanding the area of barley cultivated. In Iceland, for example, it has been estimated (Ministry of Industries and Innovation 2011) that annual production of cereals (barley) could be increased from about 16,000 t to 40,000–50,000 t per year. With the current increase in microbreweries across the region, part of this increased barley production could also be utilised to make local malt and beer. The region, therefore, has opportunities for increased self-sufficiency and sustainability by increasing domestic cereal production for feed, food and drinks.

5 Results – review of outcomes

From a value chain perspective, we review the main findings and work done in the Northern Cereals project on the barley to beer value chain. These findings are contextualised to the Northern Periphery region. However, areas with similar production constraints, where improved local malting is needed, or there is a market demand for local beer with special qualities, will also find much relevant information in this review.

5.1 New possibilities for growing, drying and storing high-quality barley

The growing season in northern areas is becoming longer, and further lengthening is expected due to higher average temperatures (Uleberg *et al.* 2014). However, it is also expected that there will be more rainfall in the autumn, especially in coastal areas. This is one of the main challenges for cereal production in the Northern Periphery region, and the project produced several country-specific reports (Martin *et al.* 2018a, 2018b, 2018c) and a peer-reviewed paper (Martin *et al.* 2017) on this topic. In Martin *et al.* (2017), the temperature and rainfall trends during

the barley growing season were investigated across the project area from 1975 to 2015. They found that a trend towards warmer growing seasons is favouring barley production and has probably been particularly beneficial in Iceland, but excessive or inadequate rainfall constrain production in many areas. They also found that “both monthly temperature and rainfall show high variability from year to year across the region, which can result in very variable growing seasons”. Such yearly variations have a high impact on production as the proportion of years with bad harvests will determine the economic viability of barley production. Another important factor for cereal production and possible expansion in the area is the availability of arable land. Arable land (here defined as the land suitable for barley cultivation) was found to be a limiting factor in many regions (Sveinsson and Dalmannsdóttir 2016). The project investigated the proportion of arable land relative to total land area and found that it is unevenly distributed throughout the Northern Periphery region, with Northern Norway having the lowest proportion (0.8%) and Orkney having the highest (15%) (Sveinsson 2017). Although Iceland had only 3% arable land, Sveinsson (2017) concluded that this area had the largest potential for increased barley production, due to the proportion of available arable land.

Well-adapted cultivars are crucial for the successful barley production in northern regions, and early maturity is a key factor due to the short growing season. Some old landraces and varieties bred in the early 1900s are still grown, and prominent among these is Bere, an ancient Scottish landrace, which has a long tradition of cultivation in Orkney. Also, in Northern Norway, four old barley varieties are preserved in addition to the landrace Dønnes (Halland et al. 2018). In the Faroes, there are two surviving landraces, Sigurd and Tampar. For the value chain from barley to beer a special emphasis was put on old varieties and landraces both because of their earliness and local adaptations (Schmidt et al. 2019), as well as their potential for telling stories about food and drink through both new and traditional barley products (Martin et al. 2009). Seed multiplication of the northern Norwegian and Faroese varieties is enabling farmers to start growing these varieties and so there is now real potential for using them for future product development. In the last 40 years, there has only been one breeding programme for adapted varieties for the region, in Iceland. The Agricultural University of Iceland has run a barley-breeding programme, which has released four commercially available cultivars (Hilmarsson et al. 2017). Among these is Iskria, which has been grown successfully in

countries within the Northern Periphery region. In the Northern Cereals preliminary project, a project supported by the North Atlantic cooperation, promising cultivars were compared in five countries (Reykdal et al. 2016). Icelandic varieties were also used in the Northern Cereals project for product development in northern Scotland, Northern Norway and the Faroe Islands.

Growing cereals in the project region requires specific agronomic knowledge. The project paid special attention to knowledge transfer and capacity building through handbooks and guidelines, which were made available in four of the region’s languages. In addition, knowledge transfer events were important tasks for all project partners. The basis for the guidelines is the review by Sveinsson and Hermannsson (2017), which relates barley physiology to the factors necessary for successfully growing the crop in northern areas. They noted that barley is the hardiest cereal species with the lowest heat requirement for growth, and that early varieties require about 1300 growing degree days (with a base temperature of 0°C) to reach maturity. Barley seeds tolerate mild frost during germination and, in this region, it is imperative for successful production that sowing should be done as early as possible. In most of the region (especially the Faroes, Northern Norway and Iceland), grain is harvested when it is physiologically mature, although at a high moisture content (i.e. usually more than 22%). This has implications for obtaining good quality malt and makes it difficult to consistently produce malting barley with the same quality criteria used by large malting companies in more southern barley growing areas (Martin 2015). In addition, as grain is usually harvested at high moisture contents, it needs to be dried to 12–14% moisture for safe storage (Reykdal 2017). This adds energy costs to the production, and it is imperative for economic viability that this is done as inexpensively as possible.

The project also investigated economic and environmental aspects of sustainability, including local production, best practices for high-quality grain and malt, and added value through new products based on place-based information and traditions. Other research has also shown that local food value chains have a positive impact on some aspects of sustainability – for example, added value at the local level (Brunori et al. 2016). In the project, a Life Cycle Assessment was performed at the Icelandic model farm Thorvaldseyri. This included looking at environmental impacts and energy-use on the farm. The results can be used to demonstrate how environmental impacts and use of resources can be minimised to improve sustainability and reduce footprint (Smárason 2016).

5.2 Local malting of barley from the Northern Periphery region

Recognising that the production of good quality local malt is dependent on growers producing grain of an appropriate quality, the project identified grain quality criteria normally required for malting barley and then developed region-specific growing guidelines to help farmers obtain grain of this quality. However, research trials associated with the project in Northern Norway demonstrated the difficulties in achieving this in more challenging parts of the region. Thus, 2015 was a good growing season with a timely harvest, and the grain had a reasonable moisture content and all seven varieties tested showed good germination and malted successfully (Thomsen 2016). In contrast, 2016 and 2017 were much less favourable for growing, resulting in later harvests, higher grain moisture content at harvest and grain with a very low germination percentage (66% and 30% from the 2016 and 2017 crops, respectively), even 7 months after harvest (Halland 2018). Low germination, as a result of seed dormancy, also challenged malt production in Iceland (Sveinsson *et al.* 2016). In contrast, in Orkney where growing conditions were more favourable, it was possible in all growing seasons from 2015 to 2017 to produce good-quality barley for malting which had lost seed dormancy by about 4 months from harvest, giving around 98% germination.

As most of the breweries involved in the project were unfamiliar with details of the malting process, a high priority was given to knowledge exchange activities related to malting. This included carrying out small-scale malting within the partner regions and making the results available through reports or case studies as well as through presentations. In parts of the region, traditional floor malting of barley is still carried out and it was recognised that this is a low-cost, easily transferable method of malting which might be appropriate for some commercial partners. The floor malting process is also ideal for demonstrating the steps involved in malting. One of the Orkney associate partners in the project was a distillery with floor malting facilities and the company agreed to malt a test batch of 7.5 t of Orkney-grown Golden Promise barley for use by an Orkney brewery and to allow the process to be documented as a case study (Martin *et al.* 2016b). Laboratory analysis of the malt showed that it was of good quality, although it had a lower extract than would have been obtained from modern malting varieties. In Norway, seven varieties grown in Tromsø were test malted at the Agricultural University of Norway

(Thomsen 2016). Malting qualities were found to vary between varieties, but the conclusion was that “we have however, so far no reason to believe that it is not possible to grow malting barley in Northern Norway.” In Iceland, test malting trials discovered large variation in germination, but were able to malt successfully around 200 kg of Iskria for further processing (Sveinsson *et al.* 2016; Sigurðsson 2018). The variation in initial grain quality is a challenge for local malting in the Northern Periphery region. To achieve good malt, it is necessary to adjust the malting process according to the initial quality. For instance, it is especially important to ensure even-sized kernels and a more even germination by screening the grain. Thomsen *et al.* (2018) addressed this in a test malting of four different barley varieties from four different regions with varying initial quality and using three different malting processes. The conclusion from their work was that the malting method chosen has a strong influence on malting quality and extract yield.

The lack of small-scale equipment for malting in the region is a constraint, but the project suggested some key recommendations for inexpensive floor malting (Martin *et al.* 2016b). These included steeping vessels that can be easily filled and emptied, a sufficiently large floor area for the scale of malting being carried out, machinery for turning the malt and clearing the floor, drying facilities that allow for temperature regulations, bagging equipment for storing the malt, as well as milling equipment. To assist further with knowledge exchange about malting, a distillery still doing floor malting in Orkney agreed to provide placements for partners from other regions to learn the technique, and eight individuals from SMEs in Iceland, the Faroes and Northern Norway took up placements. Since then, some of these have implemented their own floor malting operations.

5.3 Market potential for local malt and beer

Although it has been difficult in most of the regions, within the life of the project, to develop beers made from locally grown barley, there have been some notable successes. In Northern Norway, three breweries produced beers using local barley and one of these included a traditionally made smoky malt from a farm in Stjørdal, near Trondheim. In Orkney, Bere was used by a local brewery for producing two new beers. The same brewery also used locally grown and malted Golden Promise to produce a new beer, but preferred to use Bere, in spite of

its lower malt extract, because of its effect on beer flavour, its long association with the islands, and its unique marketing story.

The potential for higher value food and drink products from locally grown barley in the Northern Periphery region results from a global trend of increased consumer interest in both high provenance and local food and drink products (Martin et al. 2016a). In part, this is a reaction to the anonymity and complexity of today's global supply chains. The main reason then for increased local malt production is “based on a wish for local malt, greater self-sufficiency, shorter supply-chains and last but not least the special qualities obtained in these areas” (Thomsen et al. 2018).

In the Northern Periphery region, there has been an increase in the number of local food producers and microbreweries, as well as an increased focus on local food experiences in tourism. Recent data from Norway show that sales of local food increased three times as fast as the total food sales in grocery stores (Nielsen Scan Track 2016). There has also been a huge growth in tourism in the Northern Periphery region and tourists are increasingly asking for local food and drink as part of their experience (Turistundersøkelsen 2016).

In the Northern Periphery region, there has been a significant increase in the craft beer industry over the last 10 years. The craft beer revolution started in the United States in the early 1980s, but did not fully reach the Northern Periphery region until about 2010. However, in the last 5 years there has been a large increase in the number of microbreweries. In 2017, in Norway 4% of the total volume of beer sold came from microbreweries, and the Brewery and Beverage Association in Norway estimates that the market for beer from microbreweries can reach 8–10% of national sales before 2020.

In addition to using malt in beer, there was considerable interest among project associate partners in all regions in using local barley for whisky production. This reflects strong global demand for high provenance whiskies, which can be seen from the growth of premium products such as Scottish single malt whisky (Scotch Whisky Association 2018). It also stems from an expansion in microdistilleries in parallel to that of microbreweries.

6 Discussion

The project utilised various methods to tackle the different challenges (Figure 1) along the value chain from barley to beer. The review of outcomes shows that

much new knowledge was gained, and development has been achieved. For each step of the value chain, Table 3 summarises the work undertaken, the results obtained and the partners and stakeholders which were involved.

It is clear from Table 3 that the main focus in the Northern Cereals project was on the upstream parts of the value chain, growing and malting barley. However, the knowledge generated and work done on the farming part of the value chain were also used when working on the value chain from barley to food products, which was also an important part of the project. There were three main reasons for the emphasis on the upstream value chain. First, growing high-quality barley in the Northern Periphery region, especially for malting, is generally in its infancy and needs to be increased for providing sufficient raw material for making local beer. Second, apart from in Orkney, local malting was almost non-existent in the region, and new knowledge needs to be generated to obtain malt for brewing. Third, none of the R&D partners had an academic background in marketing or economics. In spite of this, the project was able to deliver upstream outcomes based on the combination of the background of the researchers and the expertise of the brewery stakeholders. Most researchers came from applied research institutes with good brewing industry links and a knowledge of the practical challenges faced by the industry in all parts of the value chain. Within the region, many microbreweries have been operating for several years, and these have good knowledge and practical experience of brewing, product development and marketing. Researchers were therefore able to rely on the expertise of the microbreweries themselves for achieving outcomes in the brewing and marketing part of the value chain.

The role of microbreweries in delivering upstream project outcomes was very much a reflection of the project's transdisciplinary approach. According to Tress et al. (2005), such an approach combines researchers from different academic disciplines as well as stakeholders, and all should work together towards a common goal where theory and knowledge are integrated. In the Northern Cereals project, the objectives sought were mainly tangible, concrete outcomes, in addition to practical knowledge building. Integration of different academic theories was, therefore, to a large degree, not needed to allow the various disciplines “to talk together” and solve common tasks. Stakeholder involvement, mainly farmers, extension workers and microbreweries, was crucial to the success of the project and imperative to achieving concrete results such as new barley production, improved drying, malting and new beer products. Although the value chain perspective of the project might have benefitted from

Table 3: Summary of methods utilised, outcomes and actors involved along the barley to beer value chain in the project Northern Cereals

Value chain segments	Farming	Malting	Brewing	Marketing
Methods	Test production Quality testing Various guidelines for growing, potential land use, sustainability and grain drying and storage Knowledge exchange	Test malting Quality testing Malting guidelines Knowledge exchange Malting placements	Test brewing Knowledge exchange	Product development Review of market situation
Outcomes	Climatic factors in all areas specified for cereal production Arable land cross the regions quantified Old varieties tested and seed multiplied in OR, FO and NO Testing of modern Icelandic varieties in all countries Quality testing of grain in NO, OR and IS Demonstration plots in OR, FO and NO Farmer handbook for growing barley in all languages Knowledge exchange, local and transnational, all regions. Farm visits in OR and IS	Test malting in OR, IS and NO Quality testing of malt in OR and NO Malting process experiments in NO with varieties from NO, IS and OR Malting guidelines in English and Norwegian Knowledge exchange in all regions Malting placements in OR for eight companies from IS, FO and NO	Test brewing of locally grown barley by microbreweries in OR, IS and NO Company visits in all regions Knowledge exchange from company to company, all regions	Product development by microbreweries in IS, OR and NO Review of market potential, all partners
Partners and stakeholders involved	R&D partners Farmers (microbreweries)	R&D partners Microbreweries External R&D specialists	R&D partners Microbreweries	Microbreweries R&D partners

FO = Faroes Islands, IS = Iceland, NO = Norway, OR = Orkney, R&D = research and development.

research partners from marketing and innovation disciplines, the shortages of grain and malt would still have been the limitation in complete value chain development. It is recommended, however, that such expertise should be included in a follow-up project to realise the full potential of local beer products.

Transnational cooperation was at the core of the Northern Cereals project. The project acknowledged that the regions (and research partners) had different strengths and challenges in the value chain, and because of this each partner concentrated on the aspects that were considered the most important locally. Table 3 shows that partners from all regions participated in many of the outcomes, and there was no outcome where only a single partner/region was involved. This shows that transnational cooperation was truly an integral part of this project.

Producing the many outcomes shown in Table 3 does not occur by transnational cooperation in itself. A good plan, appropriate expertise and careful follow-up during the project period are essential for such cooperation resulting in concrete outcomes. In addition, success depends on the nature and quality of the cooperation (Colomb 2007), and where there are historical or other pre-existing links between the partners in the project, transnational cooperation can be very important (Dühr and Nadin 2007). Partners in The Northern Cereals project came from an area where cultural–historical roots go back more than 1,000 years, and still today there are many similarities in cultural expression, food, language, social interaction, etc. In addition, the climate and environment are similar enough for the knowledge to be transferable, but sufficiently different for interesting comparisons to be made. We found that the similarities among the many partners and stakeholders strengthened the cooperation, for example, by making the many study trips and company visits of immediate relevance. One of the benefits of transnational cooperation according to Ray (2001) is “to reach critical mass”. The Northern Periphery Area is sparsely populated, and the geographical distances are long so that transnational cooperation can help overcome the shortage of critical mass for development and knowledge building. Another advantage is that it can be easier to share company knowledge with the companies in other regions and countries that are not direct competitors in the market.

7 Conclusion

We found that transnational cooperation proved to be very beneficial for achieving the aims of the Northern

Cereals project and for maximising the impact of a small pool of cereal R&D expertise spread across a large geographic region. To tackle the complexity of the challenges, a transdisciplinary approach was taken and a wide variety of practical and theoretical studies were undertaken utilising the specialist knowledge from many disciplines. The inclusion of many SMEs and other stakeholders ensured that the research was focused on overcoming the various challenges in the value chain, and made, we believe, the outcomes of the Northern Cereals project of major practical relevance to the involved parties. Although stakeholder involvement was probably the project’s main strength, the lack of academic knowledge on marketing and innovation may have been a shortcoming.

A particularly useful outcome of the Northern Cereals project has been the identification of constraints on the development of the barley to beer value chain, and addressing these should be the priority of future R&D work. Foremost among these is the development of locally adapted varieties of barley which are suitable for malting. This requires a long-term commitment to a regional plant breeding programme in which the development of malting types would be part of a wider programme of developing barley for a range of purposes. The Agricultural University of Iceland’s current programme is an excellent starting point for this, but it could be made even more effective by increasing collaboration with researchers and breeders in other northern countries/regions and by testing materials across the region. Another very specialised area requiring attention is the need for small-scale malting equipment, grain drying equipment and development of appropriate methods for malting barley produced in the region. Such facilities would be particularly valuable in the most remote areas (Iceland, Northern Norway and the Faroes). Although the project did not investigate in detail economic and policy issues, it is recognised that these also have a strong influence on barley production. For example, it is known that the lack of cereal production in Northern Norway is partly due to political reasons accompanied by lower subsidies for such production in this region (Bunger and Tufte 2016). Other important areas are product development issues related to using local barley for beer and the need for marketing and economic support to obtain maximum benefit from its high provenance. All of the above future R&D activities would benefit from a transnational and transdisciplinary approach. Although much work remains to further increase cereal production and the use of local grain in the Northern Periphery region, we

believe that this project has laid a good foundation for further progress.

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