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Local food in Iceland: identifying behavioral barriers to increased production and consumption

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Abstract

Increased production and consumption of local food may reduce the negative environmental, social, and economic impacts of industrialized and globalized food production. Here we examined potential barriers to increasing production and consumption of food produced in Iceland. First, we developed a new framework to address the behaviors of production and consumption simultaneously, to comprehensively analyze their potential barriers. We examined structural barriers by estimating the food production capacity of Iceland, and cultural and personal barriers through survey data on cultural norms and purchasing behavior from Matís, a research and development company. We found no structural barriers preventing Iceland from increasing production of local cereals, which would compliment current local production of meat and dairy and reduce reliance on imports, currently at 50% of the daily caloric intake. However, if food production became entirely local without changing the current mix of crops grown, there would be a 50% reduction in diversity (from 50 to 25 items in eight out of ten food categories). We did not identify any cultural barriers, as survey results demonstrated that consumers hold generally positive worldviews towards local food, with 88% satisfied with local food they had purchased. More than two-thirds of consumers regarded supporting the local farmer and considerations such as environmentally friendly production, fewer food miles, lower carbon footprint as important. However, they rated the local food they have access to as lower in meeting sustainability criteria, showing that they make justifications for not choosing local food in practice. This is a personal barrier to increased consumption of local food, and implies that marketing strategies and general knowledge connected to local food in Iceland might be improved. Although the results apply to the case of Iceland, the method of identifying behavioral barriers to change is applicable to other countries, regions, or foodsheds interested in assessing their food security through an analysis of local food.

1. Introduction

Feeding all people on Earth with healthy, safe, nutritious food, while maintaining a healthy environment, is a major challenge for this century (FAO 2009, Godfray *et al* 2010, Tischner *et al* 2010, Foley *et al* 2011). The overall environmental impacts of consumption are increasing beyond the gains from technological improvements (Kates and Parris 2003); this trend is seen in food by increases in dietary demand for resource-intensive foods like meat outpacing the benefits of increased efficiency and innovation in agriculture (Kastner *et al* 2012). Agriculture is the main user of water and land globally, and has major environmental impacts, including using 70% of global freshwater, occupying 38% of all terrestrial surface on the planet, and producing up to 35% of greenhouse gas emissions globally (Foley *et al* 2011, Tilman *et al* 2011).

Local food production can contribute to the sustainability of food supply systems in many ways. The 2008 US Farm Bill defines a local product as 'one that

is raised, produced, and distributed within a locality or region and is transported less than 400 miles from its origin or within a state'. More informally, local food systems are often understood to mean small-scale production systems aiming for self-sufficiency (meeting all food needs locally), loosely defined on the scale of an extended metropolitan area or 'foodshed' (within 100 miles or less), and often focusing on direct connections between producers and consumers (Clancy and Ruhf 2010). Depending on cultivation methods, locally harvested food can have lower environmental impacts than more widely sourced food (Tukker *et al* 2010). Locally grown and marketed food products can increase diversification in cultivation, local biomass return, and foodstuff diversity (Feagan *et al* 2004). However, it is not possible to make universal assumptions about the environmental benefits of local food; while it likely decreases greenhouse gas emissions from transportation, transport is not the dominant contributor of greenhouse gas emissions in the food system (Edwards-Jones 2010). While all the activities in food supply systems (the entire chain of production, processing and packaging, distribution, retail, and consumption (Ericksen 2008) have environmental impacts, the footprint of food systems is to a greater extent subject to early stages such as land use change and cultivation methods, rather than distribution (Edwards-Jones 2010).

The reconnection between producers and consumers is an important aspect of local food systems. Scaling-up is therefore a hurdle in the context of mainstreaming local food production (Mount 2012). A more comprehensive view of production and consumption must be addressed through studying the actors in food systems and their respective activities (Pretty *et al* 2010). More specifically, research connected to alternative food systems needs to demonstrate why consumers might make decisions about not buying local food, instead of the current focus around why consumers want to support local food systems and what they benefit from doing so (Tregear 2011), which ignores that fact that despite these well-known benefits, many consumers do not support these systems in practice.

A compliment to the local food perspective is a regional food system, which may include several foodsheds on a larger scale (on the order of several districts or counties, but that share geographic factors essential for production like climate and soils). Here producers and consumers may not always meet, but the connection between them is preserved. The goal is not entirely self-sufficiency, but rather self-reliance, where trade is assumed to operate but as much food as possible to meet the population's food needs is produced in the region, maximizing resilience and keeping economic and social returns within the region (Clancy and Ruhf 2010).

Iceland is a unique case where the considerations of local food are achieved on the regional and even national scale. This is because the country is small (103 000 km^2, slightly smaller than the state of Kentucky) and geographically isolated, situated in the North Atlantic Ocean, with a population of only 320 000 (Statistics Iceland 2015a), and centralized infrastructure for food production and distribution. A regional food system would traditionally include small local food systems and the definition of local food implies short distances (Clancy and Ruhf 2010). Since neither is the case in Iceland, we stress that when we use the term 'local' here, we refer to all food produced in Iceland, although the geographic scale is more typical for a regional food system. The Icelandic diet is traditionally based on meat, fish, and dairy products, with a changing trend towards a more plant-based diet in the last decades (Bonhommeau *et al* 2013). As for conditions for agriculture in Iceland, the cold climate is limiting and food security is a concern (Snæbjörnsson *et al* 2010).

Examining local food in Iceland as a case study illustrates the practical potential for countries to decrease their reliance on international trade to meet national food demand via local production, which could increase food security as well as decrease environmental impacts. Iceland is a particularly strong candidate to increase its domestic food production, as an analysis by Fader *et al* (2013) showed that more than 70% of its population relies on external land and water resources to produce major crops, placing it in the most import-reliant category along with countries such as Japan, Saudi Arabia, and Colombia. International trade for food commodities also has negative environmental consequences, including driving biodiversity loss (Lenzen *et al* 2012) and increasing unsustainable consumption patterns (Hoekstra and Wiedmann 2014), including accounting for 6% of global land use where low-income countries produce goods consumed in high-income countries (Weinzettel *et al* 2013).

In this paper, we examine both the biophysical opportunities and limitations for food production in Iceland, and the perspectives motivating consumer choice of the consumption of local food in Iceland. We assess the capacity of Iceland to grow a sufficient quantity and variety of food for its population within environmental limits, using analyses of the food supply and demand, and the inputs required to produce local food in Iceland, including the kinds of food that are possible to produce. To assess consumer demand, we surveyed both local residents and tourists. Tourism is a rapidly growing industry in Iceland, with the number of tourists doubling from 488 600 in 2010 to 998 600 in 2014, and overnight stays of foreigners increasing from 2.1 m in 2010 to 4.4 m in 2015 (Icelandic Tourist Board 2015), compared with the local population of 320 000. While tourists represent only a small fraction of total food consumed in Iceland, there is increasing interest in understanding their food preferences and marketing local foods to them as part of regional

development and tourism strategies. Therefore tourists are an important part of the food system in Iceland, and we assess the willingness of the population to transition to a more local food system through a consumer survey of tourists as well as local residents in Iceland. The purpose of this research is not to determine if the country of Iceland should rely entirely on locally grown food (self-sufficiency). The aim is rather to establish the feasibility for growing more local food in Iceland to meet local demand (self-reliance), and identify what the main barriers to the change towards a more localized food system are, so that they may be addressed.

2. Methods

2.1. Research design

We approached the issue of increased production and consumption of local food in Iceland by combining and building on two existing frameworks. The first is an environmental behavior framework based on integral theory, which conceptualizes a behavior (e.g., purchasing local food) as the result of three factors: structural, cultural, and personal, any of which could be a barrier to carrying out the behavior (Owens 2005). We represented structural barriers as relating to sustainable production, and cultural and personal barriers as relating to sustainable consumption. We developed indicators to operationalize each barrier, and collected data for measures to evaluate each indicator's contribution to the overall barrier to assess whether current conditions presented a barrier or not (table 1).

To operationalize the structural production barrier for local food, we modified a second framework, intended to assess regional food systems, developed by the Northeast Sustainable Agriculture Working Group (Ruhf and Clancy 2010). This framework posits four dimensions to regional food security: food needs and supply, diversity, natural resource sustainability, and economic development (Clancy and Ruhf 2010). These four dimensions are discussed in general terms, but particular measures to quantify them are not specified in the framework. Here we have chosen to focus on three of these four dimensions, considering economic development to be beyond the scope of this work, although we recognize that strong local food systems provide economic benefits. For the remaining three dimensions, we compared the current diet of the population (food need) with the current and calculated potential future production (food supply). We assessed diversity in terms of the current diet compared with the crops grown in Iceland. Finally, within natural resource sustainability, we started with 'availability and quality of land upon which the food supply is based' as suggested by Ruhf and Clancy (2010, p 13), and included an analysis of the resource inputs (water and fertilizer) required for local production.

On the consumption side, we considered cultural and personal barriers as described by Owens (2005), where worldviews are the indicator of group beliefs; in the case of our research we measured how consumers perceive or define the term local food. Personal barriers are psychological dynamics highlighting consumer perspectives, such as beliefs, attitudes, and awareness (Owens 2005). To measure consumer perspectives, our research quantified consumers' awareness of sustainability issues in the context of local food and investigated if consumers agree that local food actually is sustainable (table 1).

2.2. Structural barriers to local food production in Iceland

The three indicators comprising structural barriers are food needs and food supply, diversity in food production, and natural resource sustainability (table 1). The first indicator deals with the potential for Iceland to achieve self-reliance (Clancy and Ruhf 2010). There are two measures of food need and food supply: first, food needs represent the current amounts and types of food currently consumed in the country, consisting of domestically produced plus imported food. Second, food supply represents the capacity of Iceland to produce sufficient food using domestic resources, based on the suitable land available for agriculture (Ruhf and Clancy 2010). The second indicator evaluates the change in diversity of food items in the current food supply, if the food supply were drawn entirely from domestic sources without changing the crops grown. The third indicator, natural resource sustainability, evaluates the methods of production and inputs used to grow local food in order to assess the quality of the land base underlying food production (Ruhf and Clancy 2010; table 1).

Here we have focused our analysis on land as the most relevant factor for our assessment of natural resource sustainability, although unpublished analyses of marine resource management and energy use (other factors suggested by Ruhf and Clancy 2010) are available from Halldórsdóttir (2013). We did not consider their suggested indicator of transportation, as distribution of both local and imported food is centralized in Iceland, transporting imported food by sea or air to the capital and locally produced food by road, and then transporting all food through the capital by road.

2.2.1. Food needs and food supply

We calculated the food needs of Iceland in several steps, based on current consumption from the FAO Food Balance Sheet (2012). First we grouped food needs into 10 food categories, each consisting of specific food types. Next we sorted the categories based on how much each contributes to the daily calorie needs per capita (table 2). We calculated the share of imported food demand from the supply and

Table 1. This research uses three barriers to sustainable consumption identified by Owens (2005), which were operationalized into indicators assessed using quantitative measures from the data sources shown. The structural indicators were connected with measures of production based on a food system framework by Clancy and Ruhf (2010).

	Barrier	Indicator	Measure	Data source
Production	Structural	Food need and food supply	Current food needs (kcal per food category)	FAO (2012)
			Current (kcal produced) and potential (available land (ha) and yield (tonnes/ha)) food supply	Snæbjörnsson *et al* (2010)
		Diversity in food production	Number and categories of food items produced domestically	FAO (2012)
		Natural resource sustainability	Water use (share of irrigated land)	
			Land management intensity (kg fertilizer/ha)	FAO (2014)
Consumption	Cultural	Worldviews	Group beliefs	Matís consumer survey
	Personal	Consumer perspectives	Consumers' awareness about the implications of choosing local food and possible justification for not choosing local food	Matís consumer survey

utilization for primary food commodities for both imported and domestically produced food. We calculated the demand ratio as a proportion of calorie needs per capita per day by multiplying total demand (kcal/capita/day) for each category with the percentage of food supply, both for imported food and for local food. This approach enabled us to estimate what food categories are the most important to calorie intake while providing us with information about the import ratio. While these are the most consistent data available, one limitation is that FAO data only displays data in units of 1000 tonnes or more, which in some cases is too small to capture the consumption of Iceland, so some foods consumed in the country may have been missed. For example, cereals are displayed as zero in the FAO data, although horticulture, fodder and grain fields in Iceland are estimated to be 0.1% of total utilized land area in Iceland (Icelandic Farmers Association 2009), indicating that a small amount of cereals are indeed grown in the country.

In terms of food supply, we examined the potential for Iceland to produce domestic foods in the three food categories amounting to over 10% of kcal supply per capita per day, which were dairy, cereals, and meat (first three rows of table 2). Although it contributes 14% of calories, sugar was excluded from further analysis for increased local production, as there are limited sources of sugar production in Iceland, and the majority of current consumption consists of processed foods and flavored and sweetened beverages (Garcia 2013, communication by electronic mail), which are likely to continue to be imported. The potential for dairy and meat production was calculated indirectly based on the land required to supply cereals for animal feed (fodder) plus grazing land for directly raising livestock and growing grass to process into hay (pasture).

Available land for agriculture in Iceland, including grassland, is estimated to be up to 600 000 ha, which includes currently cultivated land, plus other land meeting quality criteria like maximum height above sea level and soil depth (Snæbjörnsson *et al* 2010). However, we chose to base our calculations on more conservative estimates that consider both quality and availability of the land, stating that around 200 000 ha of agricultural land are available (Hermannsson and Guðmundsdóttir 2012), while 120 000 ha are currently in cultivation for growing crops, including pasture grazing livestock (Snæbjörnsson *et al* 2010). To calculate domestic production potential, we multiplied available land by estimated yields for crops in Iceland, including wheat, barley and other cereals at 3500 kg ha^{-1} average yield (Agricultural University of Iceland (1998)).

2.2.2. Diversity in food production

Food diversity is important to the resilience of a food system, as well as for meeting consumer demand. Crops must be evaluated to see if they are in enough supply of sufficient diversity to meet the demand of the population (Clancy and Ruhf 2010). We calculated the change in food diversity if food supply were to be derived only from local sources, assuming that a decrease in diversity would be a structural barrier to change towards increased consumption of local food. We made an index of diversity by counting the number of food items that were produced locally in each of the 10 categories studied (table 2) and comparing this with the total number of items in each category for the overall supply, taken from the full FAO food balance sheet for 2009 (published in 2012). We calculated the local supply to overall supply ratio for each category and for the diet overall as a share of daily food supply in calories per capita per day, identifying the change of

Table 2. Major components of the food supply in Iceland, compiled into 10 categories from FAO (2012), ordered by contribution of calories to the diet in Iceland (shown in parentheses, compared with an average daily supply of 3292 kcals per day (FAO 2012)). Food types in the upper rows (representing 58% of total food supply in Iceland) contribute to at least 10% of total food supply and were further assessed for their domestic production potential. (Sugar was not assessed because it is largely imported in the form of processed foods). Within each category, the specific food types listed are those that contribute at least 10% to their respective category.

Major food categories	Food types
Dairy (21%)	Butter
	Milk
Cereals (20%)	Wheat
Meat (17%)	Bovine
	Mutton and goat
	Pig meat
	Poultry
Minor food categories	**Food types**
Sugars (14%)	Sugar (raw equivalent)
Oils (6%)	Olive oil
	Soya bean oil
	Sunflower seed oil
Fish (5%)	Crustaceans
	Demersal fish
	Pelagic fish
Vegetables (5%)	Potatoes
Fruit (4%)	Apples
	Bananas
	Grapes
	Oranges, mandarins
Beverages (4%)	Beer
	Wine
Beans, nuts (3%)	Cocoa beans
	Groundnuts
	Rapeseed and mustard seed

diversity in food production the country would face if solely depending on local food sources. This is not to say that a shift to entirely local production is likely, but rather to identify whether change of diversity in food supply would be a barrier to change if important food categories in the daily diet would become considerably less diverse with local production, if the crops grown did not change accordingly.

2.2.3. Sustainability of resources

The third indicator under structural barriers assesses natural resources that would be used for local food production (here represented by the need for irrigation), and the intensity of land resource management (here represented by fertilizer use). We compared Iceland's fertilizer use and irrigation with the three countries from which Iceland imports the most cereals (Denmark, Germany, and Sweden, which provide 59% of imported cereals and cereal products) (Statistics Iceland 2009). We compared fertilizer use (kg/ha of arable land) and share of land equipped for irrigation for these three countries and Iceland, using FAO (2014) food safety country profiles. These comparisons between the fertilizer and irrigation required for crop production in Iceland versus other potential sources for import indicate whether domestic production would increase or decrease the demand for water and fertilizer consumption, and thus represent negative environmental impacts from agriculture.

2.3. Cultural and personal barriers to local food consumption in Iceland

Moving from the structural barriers associated with local food production in Iceland to the cultural and personal barriers, we used a survey to assess tourists' worldviews (potential cultural barriers in the form of group beliefs), and consumer perspectives (potential personal barriers) towards local food (table 1). The aim of the survey was to identify the motives behind consumer behavior through eliciting opinions of participants, rather than investigating their knowledge regarding the sustainability of local food. The survey used a five-point scale about their agreement with the given descriptions of local food and their satisfaction with food they had purchased on their trip (table 3). The survey was conducted by the first author in collaboration with a team from Matís, a food industry R&D company in Iceland. The population of the Matís survey was a representative sample of foreign and domestic tourists, traveling in Iceland, who were approached randomly from June to August 2012, in tourist locations around Iceland. There were 463 participants that completed the questionnaire, out of which 343 were foreign (51% women, 49% men) and 120 were Icelandic (56% women, 46% men).

Ethical protocols in informed consent from The University of Iceland (2014) were followed, including informing participants about the intended use of the results for internal Matís results as well as possible academic publications, ensuring participant anonymity through not collecting names or other information indicating the identity of the participants, and reordering paper questionnaires after completion so it would not be possible to connect answers to individuals while processing the data.

2.3.1. Cultural barriers: Worldviews

We addressed cultural barriers to change through examining the cultural norms reflected through worldviews, either inhibiting or promoting change towards certain behavior (Owens 2005). We chose to examine the cultural norms connected to local food in Icelandic society by investigating consumer perception of the term 'local food,' assuming that consumers that do not seem to connect local food in Iceland to positive feelings, would indicate a cultural barrier to increased consumption of these foods. Worldview questions in the Matís survey included agreement with the idea that local food is 'healthy and safe,' in order to explore if consumers associate local food with positive

Table 3. Survey questions regarding local food and statements referring to product attributes and analyzed for the measure of personal barriers (Owens 2005) to local food consumption. Question number one asks consumers what they regard as important for local food, and question number two asks consumers what they actually think is true for local food they have access to. The bolded terms are considered sustainability criteria.

Matís consumer survey questions	
1. How important is the following in regards to local food?	Convenient packaging
	Price comparable to other products
	Product of the highest quality
	Ready for consumption
	Environmentally friendly
	Fewer food miles
	Less carbon footprint
	Supports the local farmer
2. Do you agree with the following statements about local food?	**Direct from the farm**
	Organically grown
	Sold by the producer
	Sustainably produced

statements, and the tourists' satisfaction with any local food they had purchased during their trip.

2.3.2. Personal barriers: consumer perspectives

We address personal barriers through survey questions assessing the perspectives of consumers regarding sustainability implications of local food in general, and if consumers agree that the local food they could purchase is actually sustainable, both important influences on behavior (Owens 2005). Awareness of an issue is an important precondition to making a decision, but it is not sufficient; even if we are aware of sustainable choices and the implications of our actions, we may still rationalize and justify unsustainable choices in practice (Owens 2005). For example, not believing that a product was sold by the producer might inhibit us to act in a sustainable way and thus present a personal barrier to change. The reasons behind consumers' justification of choices may be diverse, however it is increasingly recognized that 'cognitive dissonance' is a key barrier to sustainability. This describes a situation where consumers know what is sustainable and desire to act accordingly, but fail to change their lifestyles in accordance (Owens 2005).

As measures of consumer perspectives, we used questions from the Matís survey data and analyzed responses ranking the importance of attributes of local food (table 3). We assumed that high price or potential lack of convenience or quality might prevent consumers from buying local food. On the other hand, high ranking of attributes connected to sustainability issues would indicate a precondition for purchase, where consumers would be more likely to buy food on the grounds of it being local if they believe that it is a sustainable choice (table 3). We then compared if participants agreed with statements about local food, assuming that highly ranked attributes indicate that local food meets the criteria of actually being sustainable. A gap between the responses from the two survey questions would indicate that consumers are aware that local food should be a sustainable choice but fail to see that the local food they have access to actually meets these sustainability criteria, thus presenting a barrier to increased consumption of local food (table 3).

3. Results

3.1. Structural barriers to local food production in Iceland

For the current diet (food need), we found that dairy products supply 21% of the 3292 daily calories consumed in Iceland (705 kcal), cereals provide 20% (665 kcal) and meat 17% (560 kcal), with an additional 14% contributed by sugars (447 kcal), 6% by oils (202 kcal), 5% by fish (180 kcal) and 5% by vegetables (150 kcal). The remaining 12% of calories is made up by beverages, fruit, dairy, and beans, including nuts (figure 1).

In terms of local production within the ten food categories, 100% of current food supply in Iceland is provided by import for cereals, oils, and fruit. Surprisingly for a major fish producer (the country produces 1 426 000 tonnes of fish, but exports 98.9% (FAO 2012)), Iceland relies on imports for 84% of its domestic consumption. The proportion of imported sugars is 62% (with the remaining 38% largely consisting of processed foods such as sweet drinks made from imported sugar but mixed with water in Iceland and therefore counted as local). A large share of vegetables (61%), beans and nuts (50%), and beverages (39%) is also imported. The country is self-reliant for meat and 99% of dairy products are produced locally (figure 1). In total, 50% of current food need in Iceland (calculated as kcal/capita/day in the current diet) comes from imported foods (light bars in figure 1).

Out of the three categories considered for further analysis, only cereals are supplied by import (FAO 2012). The other two categories, dairy and meat, are however closely linked to the production capacity of cereals, as raising livestock requires pastureland for directly grazing animals and growing grass feed, or cropland for growing food to be fed to animals (fodder), such as cereals. Iceland is highly dependent on fodder import, growing 11 246 tonnes of barley in 2007 for fodder (Icelandic Farmers Association 2009), while importing 24 592 tonnes of animal feeds (Statistics Iceland 2015b).

3.1.1. Food supply

There is substantial unused land available in Iceland, which has the potential to be used for agriculture. It is estimated that 120 000 ha are currently used for

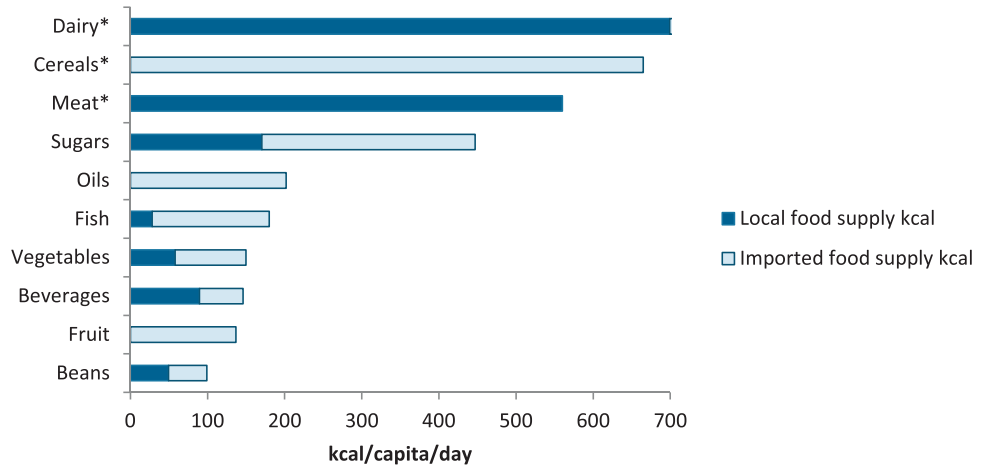

Figure 1. Imported food (lighter color) and locally produced food (darker color) for ten food categories in Iceland. For each food category, kcal supply was multiplied by import proportion and local food proportion. The top three categories, marked with *, represent 58% of the overall calorie supply, and we considered the potential for increased local production potential for those currently imported. Data for calculations from: FAO—Food Balance Sheet (2012). Raw data files for the figures are available in the online supplementary material (stacks.iop.org/ERL/11/115004/mmedia).

agriculture in Iceland, 95% of which is used as pasture for grazing animals and producing hay (figure 2). There is enough good-quality land available to increase agricultural land to 200 000 hectares (Snæbjörnsson *et al* 2010, Hermannsson and Guðmundsdóttir 2012). Based on estimates by Snæbjörnsson *et al* (2010), our calculations assume that this 200 000 ha of available land would include 137 000 ha for pasture used for grazing and growing grass to produce hay for animals, 28 000 ha for vegetables and oil crops, 21 500 ha for growing cereals like wheat (for human consumption), 5500 ha for cereals used for feed production and 8000 ha for growing other crops fed directly to animals (figure 2).

If agricultural land were increased in this way, the additional land area is sufficient to grow the amount of cereals that are currently being imported for human consumption and animal feed. The 27 000 ha for growing cereals includes 20 000 ha that are suitable for growing wheat (Snæbjörnsson *et al* 2010), with the possibility to produce 70 000 tonnes of wheat, assuming a yield of 3.5 tonnes per ha per year (Agricultural University of Iceland 2008, Bernódusson and Eggertsson 2010). This is larger than the current wheat supply of 55 000 tonnes, which is entirely supplied by import, out of which 18 000 tonnes is used for animal feed (FAO 2012).

3.1.2. Diversity in food production

Moving from production potential to consumption, if all current consumption were supplied from currently produced crops from local sources, diversity would decrease by 100% for the food categories fruit, cereals, and beans, meaning that these food categories are currently not produced in the country. Diversity would decrease slightly for fish (11%, from nine to eight food types). The decrease would be 50% for vegetables, sugars, and oils, and 75% for beverages. Iceland is however self-reliant for dairy and meat and food diversity would not decrease for those categories (figure 3). Based on the overall decrease in diversity from 50 to 25 food items in eight out of ten categories, we conclude that decreased diversity presents a barrier to overall local food production.

3.1.3. Natural resource sustainability

We found that increased local cereal production in Iceland would likely increase fertilizer use but decrease water use compared with its current producers. Iceland's use of nitrogen fertilizer is higher than two of its main import partners, indicating that some agricultural inputs would be needed to increase local production if the same crops were grown in Iceland. Fertilizer use is lowest in Sweden (45% lower than Iceland), relatively low in Denmark (27% lower than Iceland), and 2% higher in Germany than in Iceland (darker bars in figure 4). With zero irrigation in Iceland, all import partners use more irrigation, giving Iceland an advantage in water use. The share of irrigation-equipped land varies from 3% in Germany to 17% in Denmark (lighter bars in figure 4).

Compared to the reference countries, fertilizer use in Iceland is likely to increase if production would shift entirely to local sources. Fertilizer use is now 15 321 tonnes each year in Iceland, or 127.68 kg of fertilizer per ha of agricultural area in Iceland (currently 120 000 ha). Assuming that land use for agriculture would increase by 80 000 ha and the rate of fertilizer use stayed constant, fertilizer use in Iceland would increase by 10 214 tonnes (to 25 535 tonnes). Sweden is the lowest of the reference countries, where fertilizer use for 80 000 ha is 5652 tonnes, indicating that fertilizer use for comparable food items would be more if they were grown in Iceland rather than in Sweden.

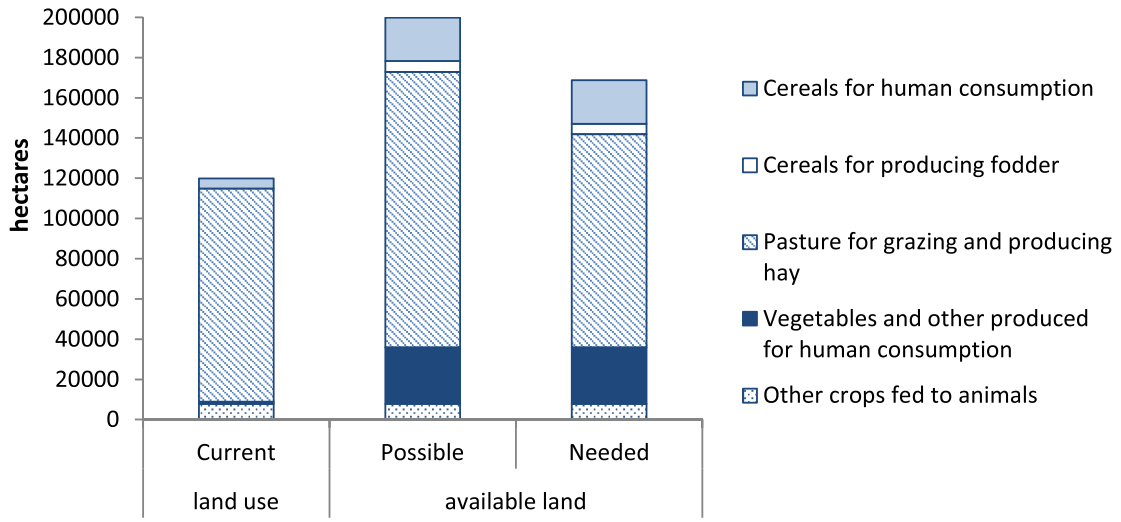

Figure 2. Current land use and available land for agricultural production in Iceland. Land use is broken down into five production categories: cereals for human consumption (lighter color bars) and fodder fed to animals (white bars); pasture for direct grazing and production of hay for animals (striped bars), and cropland for other crops, both for human consumption (darker color bars) and animal feed (spotted bars). The possible available land for each use was calculated based on data from Bernódusson and Eggertsson (2010) and The Agricultural University of Iceland (2008). Land needed was calculated by comparing the possible production capacity of available land (second bar) with current consumption from import, based on data from FAO (2012).

Fertilizer use would also be higher in Iceland than for comparable food items in Denmark, but lower in Germany. The share of crops grown on land equipped for irrigation would however decrease (figure 4). Although this comparison does not take into account different circumstances connected to the natural environment in each of the reference countries, it provides a simple overview of required inputs needed for crops grown on each hectare of agricultural land. Based on this we conclude that the overall resources and management inputs required to grow cereals in Iceland is roughly comparable to the reference countries, and that therefore this does not present a barrier to local food production.

3.2. Cultural and personal barriers to local food consumption in Iceland

3.2.1. Cultural barriers: Worldviews

A strong majority (71%) of survey participants agreed or agreed strongly that local food is healthy and safe, indicating that consumers have trust in the local food in Iceland and associate positive feelings with local food (data not shown). Of the 81% of participants who had purchased local food in their current trip, nearly all (88%) were satisfied or very satisfied with the food, with only 2% dissatisfied or very dissatisfied. This indicates that consumers in Iceland are generally satisfied with the local food they have consumed, reflecting positive worldviews towards local food.

3.2.2. Personal barriers: consumer perspectives

The majority of both Icelandic and international tourists identified the same elements as important for local food, led by the attributes of high quality and supports the local farmer, both of which were rated as important by over 80% of respondents; environmentally friendly, lower carbon footprint, and fewer food miles received more than two-thirds support; and comparable price was rated as important by around 60% of respondents (figure 5). There was a larger difference between locals and international tourists in terms of direct from the farm, sold by producer, and convenient packaging, all of which were more important to Icelanders (figure 5).

Overall, consumers found quality the most important product attribute, followed by price, indicating that consumers prioritize quality over price and convenience in driving food choices. In terms of measures of social and environmental sustainability of local foods, we found that general awareness was high, with all four of these measures (supports local farmer, fewer food miles, environmentally friendly, and less carbon footprint) rated as important by the majority. However, attitudes about local foods they consumed in Iceland were lower, with these four measures describing perceptions of local food as organically grown, sustainably produced, convenient packaging, and ready for consumption receiving between 35% and 57% agreement. This indicates that participants regard sustainability issues, such as social impacts, as important when it comes to local food, indicating that consumers are generally aware of the implications connected to choosing local food. However, in translating these general statements to views on local food in Iceland specifically, many fewer (just over half) agreed that local food in Iceland actually met these criteria (figure 5).

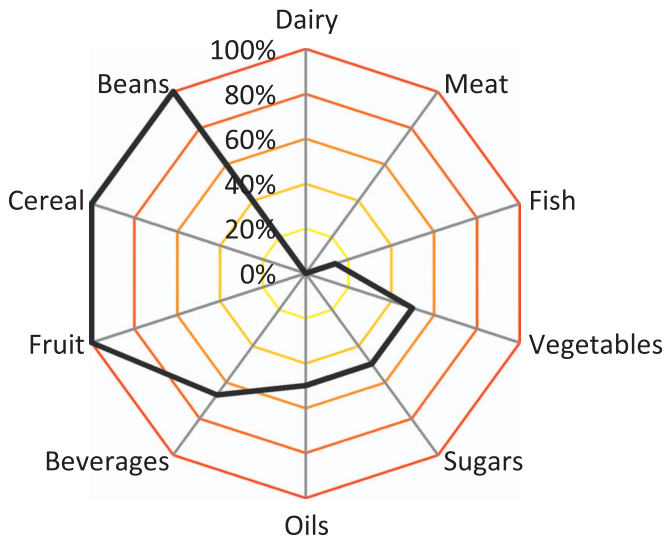

Figure 3. Change in food diversity, as measured by the number of food types for each of ten categories of food (taken from table 2, using all food items rather than items contributing to 10% or more in each category), if current food supply were replaced by entirely domestic supply assuming that no new varieties would be grown. Diversity loss would be zero for dairy and meat, which are currently entirely locally produced, and very low for fish. Vegetable, sugar, and oil diversity would decrease by half, and the decrease would be three-quarters for beverages. Fruit, cereals, and beans are currently entirely imported, leading to total loss of diversity. Food items per category compiled and rate of decreased diversity calculated using: FAO Food Balance Sheet (2012).

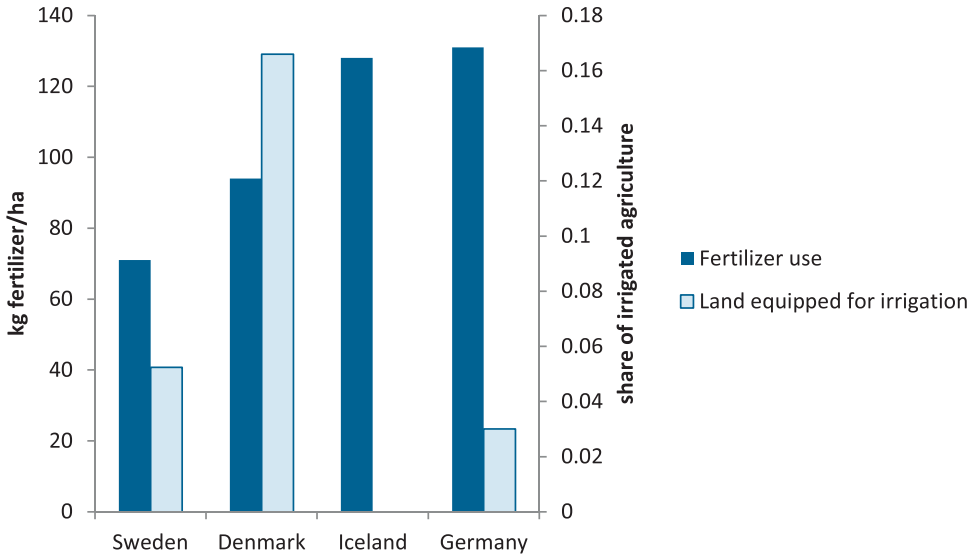

Figure 4. Comparison of fertilizer and irrigation use in Iceland with its three main import partners for cereal production. Inputs in Icelandic agriculture are high for nitrogen fertilizer use (darker bars) and low (zero) for share of arable land equipped for irrigation (lighter bars), compared to its main import partners. For calculating fertilizer use per hectare, total nitrogen fertilizer use in each country was divided by total arable land area in the country. Data from Food Security Country Profiles for the reference countries (FAO 2014).

These answers indicate that consumers do not necessarily regard the local food they have access to as a sustainable choice, even if they believe that local food in general is associated with sustainability. We conclude that the gap between awareness of local foods in general, and attitudes towards specific local foods available, represents a barrier, possibly resulting in a justification for not buying local food, even if consumers are generally aware of sustainability issues connected to local food.

4. Discussion

Our findings are that food need, food supply, and natural resource sustainability did not present structural barriers to increased food production, and that Iceland could use available domestic land and cultivation methods to produce a sufficient amount of food to fully supply the current demand for food from the top three food categories (meat, dairy, and cereals),

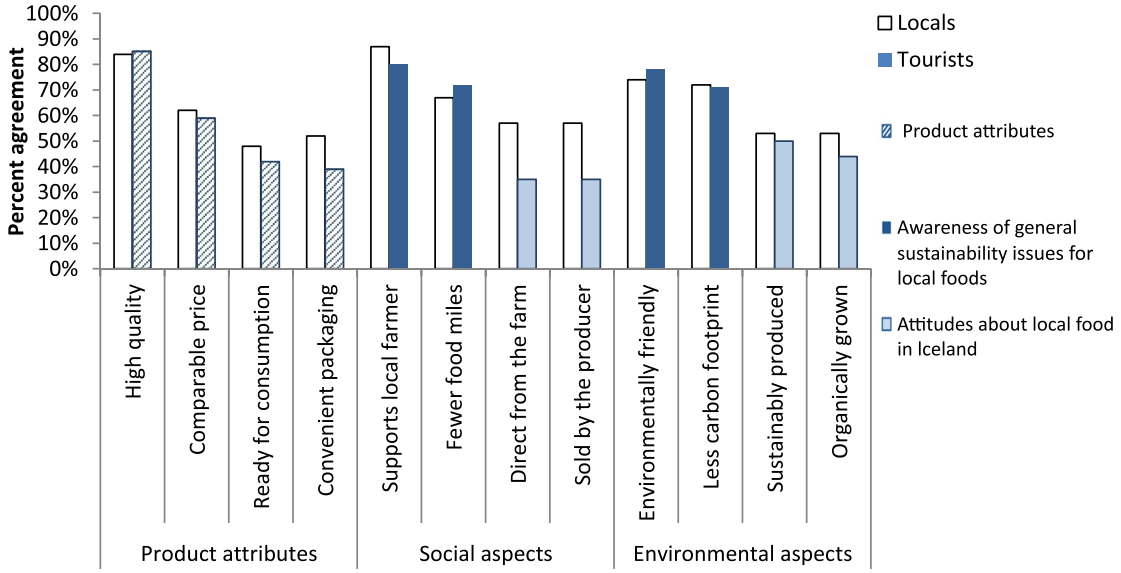

Figure 5. Survey responses from 120 Icelandic (white bars) and 343 international tourists (blue bars, showing the category of attributes represented) in Iceland about local food, showing the percent that agreed or strongly agreed with the statements presented. Consumers in Iceland rank the importance of sustainability issues in general (bars in darker color) higher than product attributes like convenience and price (striped bars), reflecting their awareness about local food in general. However they have lower levels of agreement that local food in Iceland is actually sustainable (bars in lighter color). The response rate was 89%–91%.

which in addition to existing levels of local production of foods in other categories would represent 71% of calorie consumption. However, given the currently limited range of crop cultivation, food diversity is a structural barrier to change towards increased production of local food. Worldviews of consumers were not cultural barriers. However, we identified the gap between highly positive general awareness of local food, and less positive personal attitudes about local food in Iceland as a personal barrier to increased consumption of local food.

Our findings quantifying how much more food could be produced in Iceland support the popular and political discussion in Iceland regarding food production, which widely expresses the point of view that more food could be grown in the country (Icelandic Congress 2013), and consequently less would need to be imported (Head 2011). We show that efforts to increase local food production would be most effectively focused on the major staple crops providing most of the calories consumed by people, in the case of Iceland focused on cereal crops, also keeping in mind that most of the cereal imported to Iceland is used to feed animals, and most of the increased land use for agriculture under our local production scenario was for the same purpose. As Cassidy *et al* (2013) have shown, using crops directly to feed people, rather than feeding animals, could increase available food calories by as much as 70%, or alternatively reduce the demand for cropland expansion or intensification if dietary shifts occurred.

Identifying personal barriers to change, our findings show that consumers do not favor convenience over other product attributes, but may doubt that local food in Iceland is really as sustainable as they believe local food in general to be, indicating that they justify their current choices, possibly resulting in less consumption of local food. Previous research in Ohio on consumer profiling for local and organic food found that consumers who are positive towards local and organic food tend to value attributes like support to the local farmer, health benefits, and environmental benefits (Bean and Sharp 2011), as well as valuing organic food for high quality and environmental performance (Pearson *et al* 2011). However, despite these generally positive attitudes towards organic food, these attitudes do not necessarily translate to high levels of purchase (Pearson *et al* 2011).

On the production side, we see potential for further research identifying land area suitable for growing a sufficient amount of crops, ensuring sustainable production methods. Next steps could also go beyond our assumption that the current mix of crop production would not change to identify what additional varieties of crops are possible to grow in the country, and how diverse the local food production might become as a result, perhaps using the methods of Peters *et al* (2011) to prioritize which food groups to grow locally, using spatial modeling of potential foodsheds. With work already underway towards mapping land use in Iceland (Agricultural University of Iceland 2008), there is potential to match these data with the amount of land area needed to grow the main crops, according to the most suitable soil type and weather conditions in each area of the country. Further research could also include an analysis of the diversity in types of farms,

soils, and crops, which Ruhf and Clancy (2010) have shown increases resilience in regional food systems.

Iceland has followed the global trend of increased crop diversity in the food supply, but also increased dominance by a small subset of cereal and oil crops as part of the global homogenization towards a Western diet (Khoury *et al* 2014). It is uncertain whether consumers would be willing to accept decreased food diversity if local production policies were promoted at the expense of current imports, or if they would instead demand more local production of desired foods. There are also health benefits to maintaining the current diversity of fruits and vegetables; the national dietary guidelines suggest eating at least 200 g of both fruits and vegetables per day (FAO 2015), while the current consumption falls slightly short of this goal for vegetables (185 g d^{-1}) though it does exceed the goal for fruit (250 g d^{-1}) (Icelandic Directorate of Health 2014). Further research could more comprehensively analyze the global effects from the agricultural trade of Iceland and its main importing countries, in line with Ruiter *et al* (2016) to deepen the assessment of natural resources sustainability.

To better explain the reasons and motivations driving consumer behavior, the quantitative data in our research could be complimented by more qualitative data, for example through interviews with consumers on their perspectives towards local food. This would follow the example of a qualitative study of waste reduction in Calgary, revealing that participants experienced self-deception and denial of the effects of their behavior, justifying wasteful consumption even if they were aware of the impacts of such behaviors (Owens 2005).

5. Conclusion

We see both practical and theoretical contributions of this research. On a practical level, we have identified two barriers to increased local food production and consumption in Iceland: decreased food diversity is a structural barrier connected to the current production of local food, and consumer skepticism regarding the sustainability of local food in Iceland is a personal barrier that inhibits increased consumption of local food. These two barriers are connected, for if the intention is to increase demand for local food, the supply must be in place to do so. Understanding these barriers can help focus national public policy as well as business and household decisions, all of which involve making trade-offs between different components (Ericksen 2008).

Theoretically, we have produced a new framework for analyzing barriers to local food production and consumption through merging two existing frameworks: the guidelines of Clancy and Ruhf (2010) to estimate the production capacity and resilience of regional food systems, and the integral approach as described by Owens (2005) to address barriers for consumers to make sustainable choices. This approach allowed us to address issues connected to both production and consumption of local food, which can be applied elsewhere to identify and start to overcome barriers to increased production and consumption of local food and encourage greater food self-reliance by focusing on key areas.

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