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GREENHOUSE AGRICULTURE IN THE ICELANDIC FOOD SYSTEM

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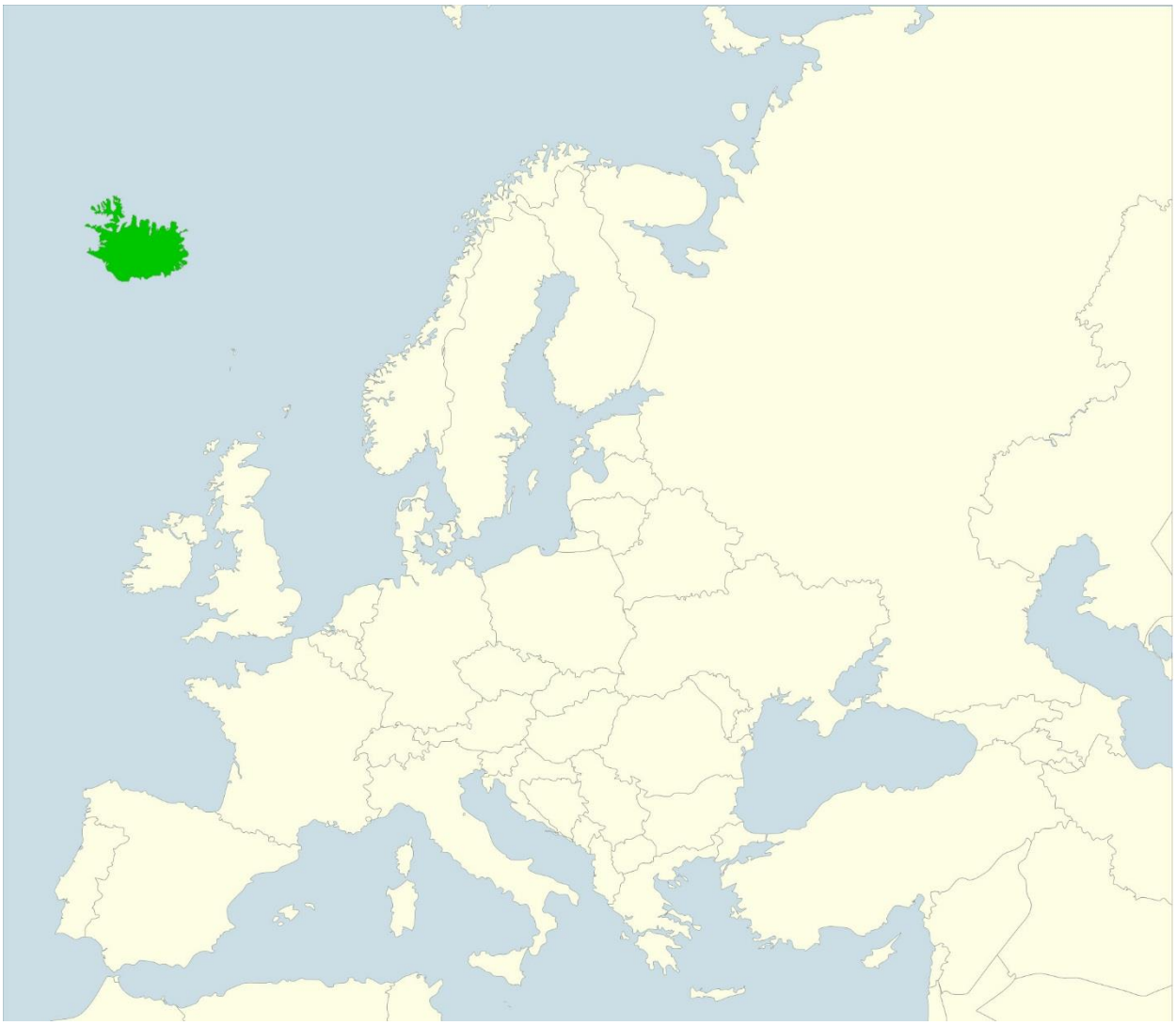

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Abstract: Greenhouses are a frequent feature on the Icelandic rural landscape and an integral part of Iceland's food system. Iceland's reserves of geothermal energy present an opportunity to extend an otherwise short growing season. This promotes sustainability, increases food security, and benefits consumers. This article examines the relative strengths of Iceland's greenhouse sector – using a combination of statistics, observations, and interviews to understand the resource demands of greenhouse agriculture, how well greenhouses can allay some food insecurity and provide local foods. It ends with an examination of how the reduction of subsidies used to keep greenhouse agriculture going, has had an effect and forces the question of whether losing much of Iceland's agricultural sector and locally sourced food is worth the social and political costs.

Keywords: agricultural geography, sustainable agriculture, food security, Iceland, food sovereignty

1. Introduction

Greenhouses are both a surprising and frequent feature on the Icelandic rural landscape. They have gained global attention in recent years due to Iceland's tourism boom and their inclusion on many popular tour bus routes. Yet, they are also an integral part of Iceland's food system, providing fresh produce to a country that lacks a temperate climate. Farmers have been harnessing geothermal heat for agriculture in Iceland for centuries. By planting crops on land directly heated by geothermal steam, early farmers were able to extend growing seasons for potatoes and grains a few months further into Iceland's frigid winters. The practice has become more sophisticated due to technological advances in horticultural sciences, and today, glass-enclosed greenhouses are a common sight across Iceland's countryside. This farming technique began out of necessity, to increase crop yields to ensure an adequate food supply for the population. Today, Iceland sources most of its food externally, so the role and future of the greenhouse industry is less certain.

Iceland is not unique in this regard. As countries develop, they tend to outsource agriculture, causing a decline in domestic food production and the conversion of farmland to other uses. This shift is beneficial and even necessary, allowing government resources to be invested in more specialized industries. However, domestic agriculture can still be an asset for countries that no longer rely on it for their food supply. In the case of Iceland, agriculture, and more specifically horticulture, has a myriad of benefits that warrant its continuation and support, including promoting sustainability, increasing food security, and benefiting consumers. Yet, the benefits of greenhouse agriculture also come at a cost. In this paper, we discussed the changing role of Iceland's greenhouses in today's globalized economy. We argue that the benefits provided by greenhouse agriculture are quite substantial in relation to food security and providing local foods, but the impediments are also daunting. This poses the question of whether subsidizing greenhouse agriculture is worth this cost.

2. Brief History

Icelandic farmers were some of the first to use geothermal heat to enrich agriculture. Records from the 1800s describe farmers planting crops in naturally heated fields because the growing season lasted longer into Iceland's frigid winters. The first known geothermal greenhouses were constructed in 1924 and improved upon the open-field method by providing protection against weather and temperature, creating a year-long growing environment. The first covered greenhouses were enclosed with natural materials, and later replaced with plastic. Most greenhouses today are glass covered, though some use plastic for small-scale or seasonal operations. Advances in greenhouse technology such as automatic watering systems and precise temperature control allow for a greater variety and quantity of crops than could ever be achieved outdoors in Iceland's climate (see Figure 1) (Ragnarsson, 2015).

Fig 1. An example of a plastic covered greenhouse, located in southern Iceland. Photo by Author

As of the most recent survey in 2012, the total surface area of greenhouses was about 194,000 m^2, of which about half is used for the production of edible plants. The remaining space is used to grow ornamental flowers and tree saplings (Ragnarsson, 2015). Nearly all of the vegetables (and a few fruits) grown in Icelandic greenhouses are consumed domestically, though there are plans to export tomatoes and cucumbers to Denmark in the upcoming year (Morgunbladid, 2017). Thanks to ever-advancing technology and near-complete control over growing conditions, seemingly anything can be grown, from lettuce and peppers to bananas and temperamental grape vines. Tomatoes and cucumbers account for a majority of total greenhouse yields, and both provide stiff competition to their imported counterparts. Figure 2 shows how these two crops have grown when compared to potatoes. In 2013, Icelandic tomatoes claimed two-thirds of the domestic market and cucumbers nearly ninety-nine percent (Samband Gardyrkjubaenda, 2015). Both of these vegetables have experienced modest, yet steady production growth between 2000 and 2015 (Statistics Iceland). Compared with horticultural produce, outdoor crop production proves to be more variable. For example, a rogue July frost in 2009 caused the loss of nearly 35 percent of the potato crop, and a particularly cold summer caused a 40 percent drop in the 2013 harvest compared with the previous year. The predictability of greenhouse crop yields compared with those traditionally grown is a testament to the industry's proficiency in overcoming Iceland's inhospitable climate (Samband Gardyrkjubaenda, 2015). While greenhouse crops do experience output fluctuations, they tend to be gradual (Statistics Iceland).

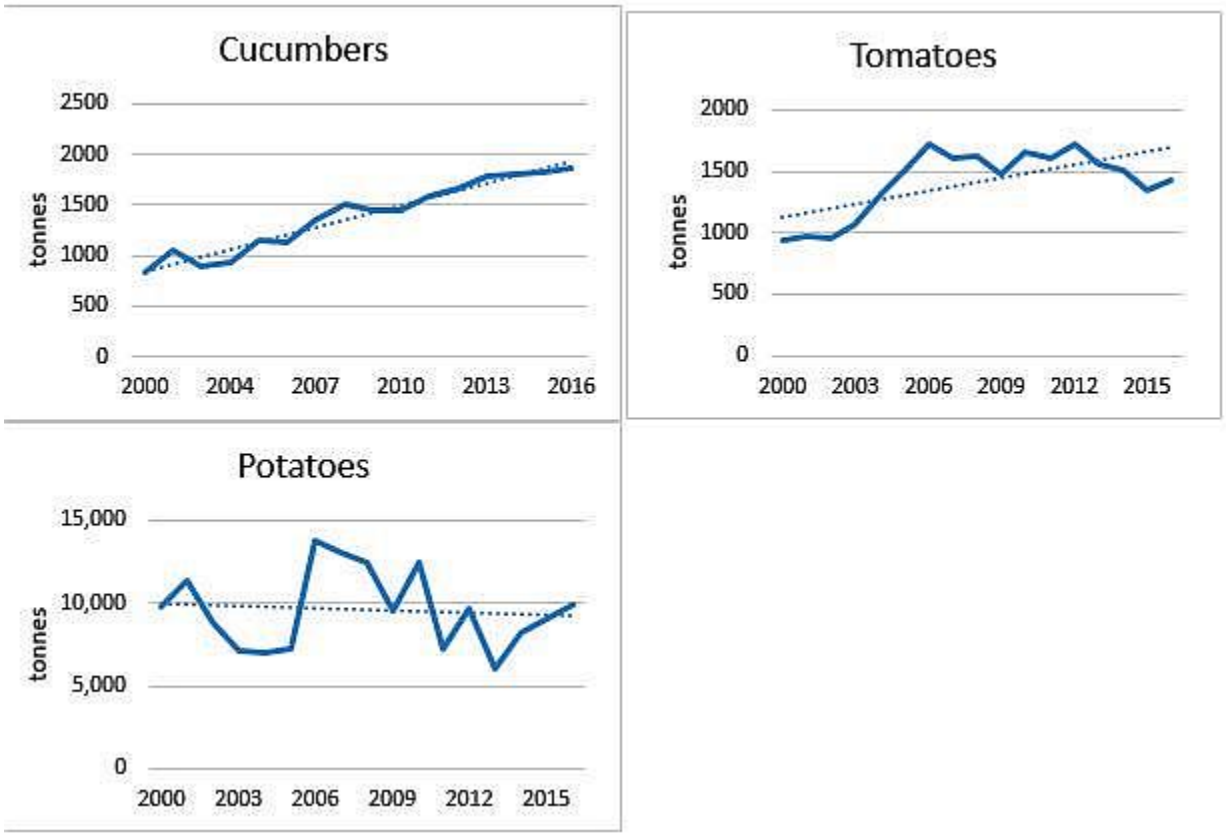

Fig 2. Growth in Production of Cucumbers and Tomatoes, Compared to Potatoes. Source: Samband Gardyrkjubaenda, 2015

Horticulture presents an advantage over traditional methods due to the ability to control all environmental factors, including sunlight, water, temperature, and nutrients. Given Iceland's sparse arable land and harsh climate, greenhouses provide the opportunity for more variety, longer growing seasons, and a greater yield of crops than could be achieved in the traditional method. Iceland already possesses and produces most of the resources needed for greenhouse operation, and food produced this way is significantly less energy-intensive than their imported equivalents. A closer examination of these key operational resources reveals both successes and opportunities for domestic, renewable sourcing.

3. Methods

Much of the data pertaining to Iceland's horticultural sector is infrequently updated or has reporting gaps. Since there is no farm structure database, details regarding facilities and consumables is largely unknown. In fact, the 2010 Farm Structure Survey cited the lack of a national farm register as a major obstacle. The survey also confirms the absence of a standardized, current database of activities pertaining to farm holdings. (FAO Farm Structure Survey National Methodological Report) In an attempt to bridge the language and reporting gaps, and to collect the personal perspectives of farmers and others involved in the industry, the first author conducted fieldwork in Iceland. Twelve farms were visited in the southwestern part of Iceland, including both open-field and greenhouse farms, and semi-structured interviews were conducted with farmers (see Table 1), a representative from the Farmer's Union, and a representative from the Ministry of Industries and Innovation. A number of informal discussions were had with farm employees, who were busy sorting and labeling vegetables during the busy harvest time.

Tab 1. Farms Visited and Farmers Interviewed.

FARM	FARMER	REGION	PRODUCE	INTVW
Friðheimar	Knútur Rafn Ármann	Selfoss	Tomatoes	✓
Garðyrkjustöðin Heiðmörk	Ómar Sævarsson	Selfoss	Tomatoes	✓
Hveratún	Magnús Skúlason	Selfoss	Herbs/Flowers	✓
Garðyrkjustöðin Engi	Ingólfur Guðnason	Selfoss	Organic Produce	
Gróðrarstöðin Kjarr	Helga R. Pálsdóttir	Selfoss	Tree Nursery	
Lambhagi	Hafberg Þórisson	Reykjavík	Lettuce/Herbs	✓
Víðigerði	Svein Magnus Andrésson	Reykholt	Tomatoes/Carrots	
Ösp	Ragnar Sverrisson	Laugarás	Tomatoes/Cucumbers	
Bökun	Vignir Jónsson	Flúðir	Carrots	✓
Brún	Birgir Thorsteinson	Flúðir	Tomatoes	
Laugarland Flúðum	Emil Gunnlaugsson	Flúðir	Herbs	
Varmalækur	Ragnheiður Karlsdóttir	Flúðir	Tomatoes	✓

A series of interviews was also conducted with a representative from Samband Garðyrkjubænda, or the Union of Horticulturalists, whose information, advice, and assistance were of invaluable importance. As someone with frequent contact and interaction with greenhouse farmers, this representative was able to provide detailed accounts of opinions and struggles they experience, information that is not easily available elsewhere. A representative from the Ministry of Industries and Innovation was interviewed to help understand the energy subsidies farmers receive, how they have changed, and discussions about the future.

4. Resource Demands of Greenhouse Agriculture

The benefits of greenhouse agriculture derive from its ability to grow food that would not be possible otherwise. Yet, these require specific resources to operate effectively. Fortunately, most of these resources are renewable and greenhouses can be quite efficient in how resources are used, particularly within the Icelandic context with abundant hydropower and water.

Nearly all the electricity produced and used in Iceland is derived from a renewable source. Around 75 percent is generated by hydropower, while the remainder is harnessed from geothermal resources (Orkustofnun, 2017a). Since this electricity is produced domestically, it has the added benefit of price stability and disruption security. Last year, Icelandic industry paid the fourth cheapest price per kWh of electricity in all of Europe (Eurostat, 2017). Greenhouses require electricity to operate, especially during the winter months when artificial lighting compensates for the lack of natural sunlight. Other electricity demands include ventilation, watering, backup heating, and computer processing (see Figures 3 and 4). Though this may seem energy intensive, agriculture accounted for only one percent of all electricity consumed in Iceland in 2016 (Orkustofnun, 2017b).

> *"About eight months out of the year, we are using the lights about 17 hours a day, but in the summer months, we can turn the lights off. In a year, our farm uses as much electricity as a town of 3,000 people. This is a lot of electricity, but it is produced right here in Iceland in a sustainable way." Knútur Rafn Ármann, - Friðheimar*

Fig 3. Automatic watering technology, regulated by a computerized system. Factors controlled include soil saturation and watering times, automatically pumping water to plants when needed through a tubing network (Photos by Author).

Fig 4. An example of a computerized system in a geothermal greenhouse in Iceland. This system automatically controls temperature, water, fertilizer, and a variety of other growing factors. (Photos by Author)

Plants need water to grow, and those grown in greenhouses are no exception. Iceland is home to 103,125 km² of glaciers, ten percent of Iceland's land area, which act as a natural storehouse of fresh water. Also considering rainfall and other water reserves, Iceland has the highest renewable freshwater availability per capita in Europe. Additionally, nearly all Iceland's freshwater does not need to be treated, which eliminates the negative environmental consequences of water purification (OECD, 2014). Many greenhouses in Iceland are hydroponic, and though water demands may seem high for this practice, vegetables grown in greenhouses require a tenth of the water demanded by their open field counterparts. This is because water is used more efficiently in hydroponic systems, reducing loss from evaporation and recycling water not used by the plants (Barbosa et al., 2015). The renewable and plentiful nature of Iceland's water supply contributes to the self-sufficiency and environmentally-friendly nature of the horticulture industry.

> *"A tomato is 90 percent water, so the quality of water is important. We are lucky in Iceland, we can water our plants with the same water we drink in our houses, and our water is plentiful and clean." Knútur Rafn Ármann, - Friðheimar*

Topsoil is a scarce resource in Iceland due to persistent erosion. The Vikings deforested nearly the entire island within three centuries of settlement, which led to desertification and a struggle to regain healthy soil ever since (Arnalds and Ármannsson, 1999). The switch to hydroponic technology substantially decreases the need for soil. Hydroponic plants grow in an inert medium, such as clay, gravel, and mineral wool, while nutrients are supplied through minerals and fertilizer mixed with the water. Stone wool is man-made mineral fiber that is used by many hydroponics farmers because it is inexpensive and reusable. In Iceland, stone wool blocks must be imported from suppliers in Denmark, which is arguably a more sustainable alternative to using scarce topsoil resources. However, many farmers use or supplement stone wool with locally sourced pumice, which is available in abundance and is an opportunity for the industry to source another material domestically and sustainably (Figure 5). Studies have proven that yields of tomatoes grown in pumice are similar to those grown in stone wool (Gunnlaugsson & Adalsteinsson, 1994).

"These rocks are from outside, from a nearby volcano. We use them to give the roots room to grow and breathe." Knútur Rafn Ármann, - Friðheimar

An additional resource benefit of greenhouse agriculture comes from their role in nurturing trees for reforestation. The barren, rocky landscape that has made it a popular set for Hollywood is also a testament to how difficult reforestation has been. When the Vikings arrived, an estimated 25 percent of the country was forested. Today, only about 1.5 percent of Iceland's area has regained woodlands, most of which has been through intentional reforestation efforts. This dramatic ecosystem change has caused a myriad of environmental problems, specifically the loss of fertile topsoil and its negative consequences for agriculture. Tree roots are essential for preventing soil erosion, so the loss of trees has resulted in widespread soil displacement and desertification (Arnalds, 2004). Soil regeneration can take decades and, if left vulnerable to the erosive forces of wind and water, can fail to regenerate entirely without human intervention (Arnalds, 2001). Greenhouses are an important factor in Iceland's reforestation efforts. Because of Iceland's short growing season, tree saplings can take twice as long to grow as they would in a more temperate climate. The optimized growing conditions offered by greenhouses means faster growth and greater capacity, allowing reforestation organizations to plant more trees each year. Icelandic law prohibits the importation of live trees, so greenhouses are essential for the regeneration of Iceland's forests and the future of farming (Fountain, 2017).

Fig 5. A stonewool block containing a tomato plant in a greenhouse in southern Iceland. The farmer has placed locally sourced gravel beneath the block for additional drainage and to reduce the amount of stonewool needed. (Photos by Author)

Fig 6. A container of fishmeal produced by an Icelandic fishmeal plant in southern Iceland. The fishmeal is directly applied to crops, both indoors and outdoors, to supplement the soil with additional nutrients to aid growth. (Photos by Author)

Overall, geothermal greenhouse agriculture in Iceland is a highly self-sufficient industry with fewer harmful effects and even beneficial impacts on the environment. Many of the daily operating inputs, especially electricity and water, are already sourced entirely locally and sustainably. Though stone wool is reusable, it is a manufactured product that must be periodically imported, so the switch to locally pumice would be a more sustainable alternative growth media. There is

also an opportunity for fertilizer to be sourced domestically. While there is no official survey of horticultural fertilizer use and sourcing, many farmers we interviewed used imported fertilizer. There were a few exceptions, specifically organic farmers who use fishmeal as a domestic and sustainable fertilizer (Figure 6). Though these farmers are enthusiastic about its potential, synthetic fertilizers still seem to dominate the demand.

5. Increasing Food Security

Though food security is typically discussed in the context of developing countries, industrialized nations also face threats to a sufficient food supply. According to a 2004 report by the World Bank, nearly two-thirds of developed nations lack the internal infrastructure to produce and distribute enough food to feed their populations. Reliance on imported food poses an often-overlooked threat to food security, namely the consequences of disruption in global supply chains (Ng, 2008). Examples of factors that have affected food supply networks include natural disasters, political conflicts, and economic crises. Iceland's vulnerability to disruptions was starkly revealed during the recent financial and environmental troubles, proving that food shortages quickly follow an interruption in the import network.

Iceland began as a Viking settlement, whose isolation demanded total self-sufficiency and resourcefulness. Today, Iceland is an autonomous and wealthy nation that effectively relies on other countries for half of its food supply including many essential products. In addition, other inputs necessary for food production must be imported (Bailes and Jóhannsson, 2011). The history of Iceland's shift from self-sufficiency to import-reliance reveals that as it became more dependent on external food, the domestic agricultural sector weakened significantly. Following the trend in other developed countries, Iceland lost the capacity to feed its population and became vulnerable to fragile trade networks, as evidenced by two recent instances of food shortages; the 2008 financial crisis and the Eyjafjallajökull eruption in 2010.

After the financial crash, food importers were hesitant to do business with Iceland amidst the uncertain economic climate, and many suppliers temporarily halted business. There was a short period of panic in which some Icelanders hurriedly purchased food from grocery stores and warehouse supplies dwindled rapidly. Although import networks were restored before food supplies ran out, the food scare prompted the Icelandic government to sanction a report entitled the Icelandic Risk Assessment Report (IRAR) that examined Iceland's food insecurity (Bailes and Jóhannsson, 2011). The report found that if food imports were discontinued, Iceland would be unable to feed its population. Suggestions for improvement include establishing grain stocks, contingency plans, and conducting further research in the area of food security in Iceland (Ministry for Foreign Affairs of Iceland 2009). Despite the proactive and preventative spirit of this report, it ultimately resulted in little action.

Shortly following the financial crash was a natural crisis that further exposed Iceland's vulnerability. The Eyjafjallajökull volcano, located in the southern portion of the country, began erupting on March 20th, 2010 and continued until late May of the same year. The eruption was explosive, expelling volcanic ash several kilometers into the atmosphere (Gudmundsson et al., 2010). While glacial flooding and lava flows were damaging to the immediate area surrounding the volcano, the atmospheric ash proved to be the most disruptive consequence of the eruption. The ash pollution was heaviest in the south of Iceland near the volcano, which happens to be where most of Iceland's farms are located. Croplands were blanketed with ash, which severely damaged and destroyed yields for the year. Livestock operations lost cattle due to respiratory problems resulting from poisonous smoke and ash inhalation. Not only was Iceland's internal food infrastructure affected by the volcano, it also temporarily interrupted food importation. Atmospheric ash halted air traffic due to the dangerous nature of flying under these conditions. Food that was normally transported via airplane was not able to reach Iceland, and a few minor food shortages were reported as a result (Bailes and Jóhannsson, 2011).

These events indicate a need for Iceland to consider its vulnerability to food insecurity, and to protect its food supply from the unpredictable nature of international trade. While it's true that outsourcing food production is economically beneficial and even necessary, the consequential vulnerability it causes is undeniable. To mitigate this security threat, domestic food production

and distribution networks can be preserved, not as a replacement for imports or to reach self-sufficiency, but as a temporary food supply to safeguard against disruptions. In addition to other local food systems such as lamb and dairy, greenhouse agriculture in Iceland is a sustainable industry and presents the unique advantage to grow food year-round and weather independently.

6. Providing Local Foods

Over the past few decades, consumers across the globe have developed a growing interest in the source, quality, safety, and sustainability of their food. Colloquially dubbed "the local food movement," it is comprised of several objectives, including reducing greenhouse gas emissions, opposing large food corporations and retail chains, strengthening family and community bonds through food preparation and sharing, and supporting local farmers (Martinez, 2010). In addition, food can often be seen as an emblem of national identity and the image of local food, counterpoised against a faceless globalizing culture, can influence consumer behavior (Raento, 2010).

Icelanders have an overall positive view of locally sourced foods. According to a 2016 study, over 70 percent of Icelandic consumers think local food is healthy and safe and over 80 percent are satisfied with the quality of their purchase. Survey respondents emphasized the value of supporting local farmers and lowering environmental impact, and are willing to pay slightly (but not too much) more for food grown in support of these causes (Halldórsdóttir and Nicholas, 2016).

Locally grown food is also a source of national pride. Many Icelandic food producers capitalize on "food nationalism" through marketing that emphasizes the Icelandic nature of their products. For example, Smjör is a major butter producer in Iceland that prominently features the phrase "Icelandic Butter" on its products. The company website has a pastoral Icelandic countryside as its header and on the homepage, a written history of butter-making back to the 10th century, complete with black-and-white photo of a man hauling milk (Smjör, 2018). Like many other local producers, Smjör uses Icelandic nationalism to add value to their products due to positive consumer perceptions of their country.

The greenhouse industry has also capitalized on the local food movement. A branding campaign led by a distribution and marketing company has spearheaded a labeling effort to differentiate Icelandic-grown produce from their imported counterparts. Íslenskt Grænmeti (Icelandic Vegetables in English) supplies farmers with labels bearing the farm name, type of vegetable, the Icelandic flag, and the word "Íslenskir", which translates to "Icelandic." (Islenska, 2015). Many of the farmers interviewed for this paper expressed enthusiasm for labeling their produce, and felt the differentiation from imported options, even if sometimes less expensive, improved sales.

> *"I think these labels are good for my tomatoes, people are happy to know they were grown right here in Iceland." - Ómar Sævarsson - Heiðmörk*

Further proof of the demand for domestic vegetables can be found in the outrage that resulted when a supermarket chain was suspected of misrepresenting the origin of their tomatoes. The store was accused of mixing foreign and domestic tomatoes then selling them as Icelandic (Morgunbladid, 2012).

Given the enthusiasm among Icelandic consumers for local foods, one would assume the Icelandic horticultural sector would be met with overwhelming support. And indeed, the success of Íslenskt Grænmeti's branding campaign indicates perceived value-added for food produced in Icelandic greenhouses. However, Halldórsdóttir and Nicholas's 2016 study found that some consumers question the sustainability of food grown in Iceland, which presents an opportunity to identify these reasons and improve this perception. The researchers acknowledge the impracticality of an entirely local food economy in Iceland, especially as it relates to drastically decreased food diversity, while also highlighting many realistic opportunities for domestic production and sourcing.

7. Subsidizing Greenhouse Agriculture and Impediments to Its Future Growth

Despite environmental sustainability, benefits to food security, and general Icelandic consumer support, the future of horticulture in Iceland is uncertain. The industry requires both governmental subsidies and protective tariffs to mitigate operating costs and remain competitive against imports, a practice that has proven controversial. Though Iceland has frozen its bid for EU membership, these interventions were considered incompatible with free trade agreements and would have required amending if the bid had proceeded. On the other hand, it could be argued that Iceland's environment and geography is unique and requires more support and protection to remain viable.

Iceland has one of the highest levels of support of agriculture among countries in the Organization for Economic Cooperation and Development (OECD) and accounts for 1.2 percent of the country's GDP. Budgets are set by the Ministry of Fisheries and Agriculture and implemented by the Farmer's Association, and are often negotiated and revised (OECD 2014). The outcomes of these negotiations must be in accordance with the World Trade Organization Agreement, more than twenty Free Trade Agreements within the EFTA (European Free Trade Association) states, the EEA (European Economic Area), and agreements with Norway and the Faroe Islands. The future of greenhouse agriculture, and indeed all agriculture in Iceland, is dependent on governmental support of the industry. There are three ways in which Iceland has supported its greenhouse agricultural sector: tariffs, energy subsidies and direct payments.

Tariffs have proven successful in allowing Icelandic meat and dairy to be competitive in the domestic market. The policies are flexible and tariffs are lifted when Icelandic products are unavailable to protect Icelandic consumers against unnecessarily inflated food prices (Bændasamtök Íslands 2012). Greenhouse products were protected by a 30 percent customs duty until 2002, when an agreement was reached to abolish import taxes in favor of other forms of support. This change was followed by a rapid decline in greenhouse production. Domestic produce struggled to compete with less expensive foreign competitors, and many farms went out of business. Total greenhouse area was reduced by over eight percent – from 204,000m^3 to 187,000m^3 – in the year following the import tax drop, and ownership dropped approximately ten percent, from 119 to 107 owners. Neither greenhouse counts have resumed the levels achieved before the policy change of 2002 (Bændasamtök Íslands 2013). While it is impossible to determine if abolished tariffs was the reason for the decline, the coincidence has left many farmers demanding more protective tariffs, despite a ten percent reinstatement in 2007.

One of the concessions for eliminating tariffs was payments for electricity costs. The government issued grants for energy-efficient lighting equipment and increased electricity subsidies. Directly following the payment agreement in 2002, subsidies were roughly 40 percent of the average income and mainly contributed towards the costs of distributing electricity (Bændasamtök Íslands 2012). However, the subsidy budget failed to keep up with inflating electricity prices and a doubled demand across the sector. In response to the unforeseen expense growth, the government lowered support by 30 percent. As a result, farmers limited their production and yields dropped dramatically despite market demand for Icelandic vegetables (Samband Gardyrkjubaenda 2015). Interviews with greenhouse farmers revealed frustration with prohibitively high energy costs and the feeling that the government is not providing adequate support.

Bjarni Jónsson, managing director of the Icelandic Association of Horticultural Producers, voiced concern about growing electricity costs, noting that farms were forced to scale back production despite market demand for their products (Jonsson, 2012). Laugarás greenhouse farmer Ragnar Sverrisson stated, "I can't make ends meet with these prices" during a 2009 horticultural producer protest (Iceland Review 2009).

Like many island nations, the cost of agriculture and transportation is higher in Iceland than in neighboring countries, so the industry requires greater financial support to remain viable and competitive (Bændasamtök Íslands 2012). And indeed, agricultural support in Iceland is well above average. As of 2013, 44 percent of gross farm receipts were direct payments from the government, compared with the 18 percent average across OECD (Organization for Economic Cooperation and Development) countries. Support is so high, in fact, that a 2011

European Union membership screening report found Iceland's policies grossly unsuited to the EU's Common Agricultural Policy, specifically citing direct payments and electricity subsidies as areas needing revising (European Union 2011). Though EU membership negotiations have been frozen since 2012 and withdrawn completely in March of 2015, the screening report findings raise important questions regarding the future of agriculture in Iceland. If the agricultural sector continues to struggle despite such robust support, this may be proof that farming is not profitable. The question is whether the market should be allowed to dictate the fate of the industry or whether the investment in food security is invaluable enough that it should be supported at all costs.

8. Conclusion

While Iceland relies heavily on imported food, it still benefits from a robust agricultural sector. Domestic food production can safeguard against the unpredictable nature of international trade networks and allow for the provision of locally sourced food. One way in which Iceland has been able to overcome some climatic limitations are through the development of geothermal greenhouse agriculture. Greenhouse agriculture can provide a year-round food source that is both steady and nutritious. However, for it to be effective requires the support of the government, which currently takes the form of direct payments and protective tariffs. National expenditure is proportionally high compared with other European countries, leading some to question the viability of agriculture in Iceland. We would also argue that a comprehensive and regular farm survey needs to be done in order to accurately access the environmental sustainability, and opportunities for sustainability, of the industry.

Our research looked at the costs and benefits of greenhouse agriculture on the ground, through interviews with local farmers and agricultural officials. The most prominent concern among farmers was that of governmental policies which both protect and support the industry, and how the fate of the industry is largely dependent on these legislations. These include protective tariffs on imported goods, subsidies for electricity costs, and production quotas. The farm visits provided valuable insight into some common practices, including types of growth media, fertilizers, and automated systems, factors which are infrequently reported on in the literature.

We find that there is significant market demand for greenhouse products, and that greenhouses can help with food security and local foods. Moreover, greenhouses also benefit from renewable resources. At the same time, greenhouses do require electricity and have depended on significant government subsidy. These subsidies have decreased over the last several years, and there has been a resulting decline in greenhouse production. The question is whether Iceland decides that losing much of its agricultural sector and locally sourced food is worth the social and political costs.

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