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Greenland, Climate Volatility

Greenland: Growing food for millions to come

Greenland is known as the land of the midnight sun. With average temperatures ranging from negative thirty-four degrees Celsius to seven Celsius, Greenland's climate is far from ideal for farming ("The World Factbook: Greenland"). Greenland's population is 56,636 as of February 26, 2019 (Greenland Population (LIVE)"). With a total landmass of 836,000 square miles, Greenland is the largest island in the world (Pedersen). However, only 158,000 square miles of that land is ice free. That means that only 18.8% of Greenland can be used for farming. In 2011, less than a thousand acres (only 0.6%) of that land was being used for permanent pasture ("The World Factbook: Greenland"). Yearly precipitation is 15 to 25 inches. Soil forms slowly and consists mainly of gravel making deep root systems impossible. Greenland's climate has wind speeds averaging 9.7 MPH per day (*The Tundra Biome)*. Since Greenland has a harsh climate, typical farming methods are not applicable. Therefore, climate independent farming methods such as aquaponics, hydroponics, and aeroponics may prove to be viable solutions to this problem. This proposal maximizes the utilization of Greenland's available arable land for food production.

A large part of Greenland's economy relies on the fishing industry. "The 2013 export in Greenland amounts to approximately € 366 Mio. with the main part (88 %) being fish and shellfish, making the Greenlandic economy vulnerable to international price fluctuations. In 2013, almost 47% of Greenland's exports came from cold water shrimp, 26% from halibut and 15% from other fish (namely cod and crabs). In 2013, 2% of the export derived from mining containing mainly gold and olivine" ("Economy and Industry in Greenland"). According to the Central Intelligence Agency's World Factbook, Greenland spent 783.5 million US dollars on imports in 2015. However, Greenland only made 407.1 million dollars from its exports. Their top imports include machinery and transport equipment, manufactured goods, food, petroleum products, and their top exports include fish and fish products ("The World Factbook: Greenland").

Even with all the fish and fish products Greenland produces, it still imports close to $90 million USD of food and agricultural products every year. Greenlanders don't produce enough of their own food, they spend an average of 44 percent of their $33,000 yearly income on imported food ("The World Factbook: Greenland"). In contrast, the United States spends an average of 6.4 percent of their income on food and Kenya spends 46.7 percent of their income on food ("Overview."). Since a large majority of Greenlanders budget is spent on food, hunger and malnutrition could come into play.

On the domestic front, the average family in Greenland spends $277.12 US dollars on food every week (Menzel 145). Seventy-two percent of their food budget is spent on imported food, which places a tremendous burden on Greenlander families. Most of the imported food is transported by boat which is dangerous and expensive because of the distances involved, and navigational concerns such as weather, icebergs and glaciers. Additionally, it uses large amounts of non-renewable resources to transport these goods. It is difficult to import food to Greenland; yet, Greenland must heavily rely on imported food.

Importation and climate volatility are contributing factors to child hunger and nutritional deficiencies in Greenland. A national report on the food policy of Greenland was published by the Greenland Home Rule Government in 2004. This brought awareness to the prevalence of food insecurity that existed among

Greenlandic children. From this report, it was found that 11 percent of children in the ages 11 to 16 reported “often hungry” or “always hungry” when they were going to school or going to bed (“Child Hunger in Greenland”). One out of ten Greenlandic children reports they don’t know where their next meal is coming from. In addition, the typical Greenlander’s diet can result in nutritional deficiencies. The most common deficiency is a lack of Vitamin C. Deficiencies in Vitamin B1 (Thiamine) and B2 (Riboflavin) are also reported, but are less common than that of Vitamin C. The traditional Greenlandic diet relies so heavily on wild seafood, much of which contains high levels of heavy metals and organochlorines due to pollution. This concentration of “contaminated foods" can lead to additional health problems over time. The best way to solve this problem is to find a practical, economical and efficient way to help Greenlanders overcome their hostile environment and overwhelming reliance on imports. (Andersen)

The most obvious way for Greenland to reduce its reliance on imported food is for Greenlanders to start producing more of their own food. As stated above, the climate in Greenland is inhospitable. According to the smithsonian.com, Greenland lost 12.5 billion tons of ice in a single day. That is enough ice to cover all of Florida in five inches of water (Solly). In July alone, 197 billion tons of melted ice raised the sea level by 0.5 millimeters. “By 2100, Greenland’s ice loss and surface melting could contribute another two to thirteen inches of water to this figure” (Solly). While global warming may expose more land, this land would be considered Arctic Tundra and is not likely to be useful in conventional agriculture. Arctic Tundra is noted for its frost-molded landscapes, extremely low temperatures, little precipitation, poor nutrients and short growing seasons (*The Tundra Biome).* While the scope of Greenland’s trade imbalance and lack of arable land combine to create a formidable problem, this problem is not without solutions.

One practical, economical, and efficient way to address this problem is through the use of hydroponics, aeroponics, and aquaponics. “Hydroponics, by definition, is a method of growing plants in a water-based, nutrient-rich solution. Hydroponics does not use soil. Instead, the root system is supported using an inert medium such as perlite, rockwool, clay pellets, peat moss, or vermiculite. The basic premise behind hydroponics is to allow the plant's roots to come in direct contact with the nutrient solution, while also having access to oxygen, which is essential for proper growth” (“Hydroponic Systems 101”). Hydroponics systems consist of a large basin with a column. Surrounding the column are long cylindrical lights. The column has many holes with filters. That is where the inert medium and the seed are placed. A pump in the basin draws the water up to the very top of the column. The water then trickles down the column providing water to the holes, thus allowing the plant to grow. Hydroponics can also be horizontal. A flat horizontal plane has many holes with filters. A pump, connected to a water supply, pumps water underneath the plane, giving water to the plants within the holes. Nutrients and fertilizer must be added to the water to maintain plant health. Hydroponics systems are good for growing tomatoes, herbs and lettuce.

Aeroponics is a more extreme form of hydroponics. Aeroponics involves suspending plants in the air on a rack in an inert medium and misting them every 15 minutes. As the plant outgrows the medium, the roots wrap around the rods that make up the rack, holding the plant in place without the use of soil or a medium. Nutrients and fertilizers need to be added to the water. Aeroponic systems grow strawberries, tomatillos, eggplant, watermelon, tomatoes, and kale varieties very well.

Aquaponics is very similar to hydroponics, but instead of only growing plants, one can produce fish (a nutritious protein source) as well. Aquaponics involves a flat plane with holes that have a filtered bottom. In a separate yet connected area, fish live. As the fish excrete, the nitrogen in the excrement gets pumped through the water, giving the plants much-needed nutrients while the plants provide oxygen for the fish. Other aquaponics systems have a separate fish tank that is connected to beds through pipes. One bed is a float bed where plants are grown in a hole in a thick piece of Styrofoam that freely floats. The other is a

media bed that is full of clay pebbles with the water underneath. The plants are directly inserted into the pebbles and the roots grow deep to reach the water. This system grows melons, tomatoes, cucumbers, lettuce, herbs, and tilapia very well. Aquaponic systems also routinely produce, peppers, peas, beans, and broccoli and have been used to grow bananas, onions and even dwarf citrus trees such as lemons and limes and oranges ("Commercial Aquaponic Systems from Nelson and Pade. Earn profits from aquaponic farming.").

In addition to tilapia, aquaponics systems can support other species of fish, including, but not limited to trout, carp, catfish, bass and perch. Since halibut is the species that is most commonly caught offshore of Greenland, this species could be a possibility for the aquaponics systems. Halibut is being farmed in other countries such as Norway and Iceland. In addition to fish, certain crustaceans such as freshwater prawns, crayfish, and mussels can be grown. Mussels are particularly useful as they are filter feeders and can help keep tank water clean ("Fish Species Suitable for Aquaponics System."). By implementing aquaponics, Greenlanders can become more self-sufficient in foods that are healthy while containing the proper vitamins and minerals needed in their diets.

Aquaponic, aeroponic, and hydroponic systems could all be utilized in Greenland. Any of these systems would help because a larger variety of fruits and vegetables could be grown to diversify the food supply of Greenland and help support the population. As an aquaponic system is able to produce a greater variety of food and especially citrus fruits to combat nutritional deficiencies and pollution-free seafood to counter long term exposure to heavy metals and organochlorines, logically, aquaponics systems are the most suited for Greenland.

Since one in ten children don't know where their next meal is coming from, implementing aquaponics in a school setting could be beneficial. Private grants are available that could cover the cost of a small aquaponics unit. Students would take a hands-on approach to learn about the aquaponics system, agriculture, and nutrition. The harvested food would then be donated to the school lunch program to help feed their own students. This provides a more diversified diet for children without the dangers of importation. This practice encourages students' interest in science and could have an unexpected benefit of creating a better, trained and more educated workforce. Marmaton Valley High School in Moran, Kansas, received a $5,000 grant to buy an aquaponics system. All the produce that was harvested throughout the school year was donated to the kitchen staff and was used in school lunches.

Other advantages of using hydroponics, aquaponics, and aeroponics are that once they are running, they don't require intense manual labor because they are self-sufficient. Additionally, different vegetables and fruit can be harvested year-round because it is indoors. Aquaponics, hydroponics, and aeroponics don't require that much energy either. A large aquaponics system consumes anywhere from $39 to $112 U.S. dollars a year in electricity.

An additional benefit is that Greenland uses hydropower to generate energy for three major cities. Hydropower is a renewable and clean way to produce energy for thousands in large cities. This system would be another positive by-product of implementing aquaponics. Another renewable source of energy that could be used to power an aquaponics system is solar power. During the summer, the sun never sets giving them 60 days of full sunlight. Using batteries, they could store this energy to use during the winter when there is no sunshine. This would be a higher investment. However, the cost could be recouped within ten years. Another way to help defray costs is by using rain to supplement the growing systems. Greenland gets approximately thirty-two inches of rain a year ("Data.org"). By collecting this rain in barrels, this rainwater can be used in the aquaponic systems. By using their natural resources to their advantage, Greenlanders can capitalize on using uninhabited land to better advance this new industry.

Aquaponics can also provide a unique opportunity for inland fish farming. Since fishing is the biggest industry in Greenland, having inland fish farms could help feed the population. Any surplus fish produced could be exported to other countries. Aquaponics could be a potential solution to another problem: overfishing. Due to concerns about the sustainability of fish populations in the wild, fishermen are actually being paid not to fish off the Greenland coast. With aquaponics, fishermen can continue their traditional occupations in a new and more sustainable way. Finally, fish raised in a closed aquaponics system are not likely to have the chemical and metal contamination found in their wild brethren.

Other countries have started implementing a more commercial use of aquaponics, hydroponics, and aeroponics. Take, for example, GrowUp Ltd. in London, England. They converted an old, abandoned warehouse into a successful aquaponics farm. In 8,200 square feet, they produced over 20,000 kilograms of salads and herbs and 4,000 kilograms of fish yearly ("Aquaponics in the World"). With their expertise they have found that the scale of aquaponics farming is important. They have recently updated to a larger facility that will help them make more of a profit. This shows aquaponics works and can be successful.

However, the promise of aquaponics comes with a substantial cost and the funding of large-scale aquaponics systems might prove a challenge. Greenland's budget has been in a deficit since 2014, so the likelihood the government would or could subsidize aquaponics is limited. The best solution would likely be a combination of private and government funding. As always, the obstacle is getting well-established businesses interested in coming to a country with such a volatile climate, small population and limited opportunity for expansion.

This view is shortsighted as Greenland would prove to be the ultimate advertisement for successful implementation of a stable and functional aquaponics system in a harsh environment. While the financial success of a project in Greenland might be fleeting, success in that area would likely lead to opportunities to employ similar systems in wealthier areas such as China and the Middle East. The other challenge would be for individuals already living in Greenland to start up an aquaponics business, knowing that they most likely won't earn a profit for at least three years.

Implementing an expanded large commercial system costs $190,000 ("Commercial Aquaponic Systems from Nelson and Pade. Earn profits from aquaponic farming."). This figure does not include building, labor, or utility costs. The size of this building would need to be at least 17,430 square feet. With this system, they could harvest approximately 500 lettuce plants a day. Additionally, they could harvest 800 lbs. of fish every month. The gross profit for a month would be $34,200 before operating costs. In estimation, it would be three years before they ever turned a profit.

This proposed operation would be twice as big as the Grow Up Ltd. model version being done in England, and so in theory, would produce more than twice the amount of food making it more profitable. This system would help diversify the food supply of Greenland as well as support the population and allow Greenland to stop relying so heavily on imports. Greenland has the available acreage to support these endeavors. With the right business support and entrepreneurial spirit, Greenlanders have the chance to become a more healthy and self-sufficient nation.

Greenland presents both a challenge and an opportunity. They have the land area and resources to become a large producer of food if they can overcome their hostile, cold environment. The future of agriculture is in technology. Aquaponics, hydroponics, and aeroponics would help diversify the food supply of Greenland, support the population and reduce Greenland's heavy reliance on imports. This solution is environmentally safe. By making this technology more accessible to countries with hostile climates, a big step can be taken in feeding the world. If aquaponics, hydroponics, and aeroponics can be

implemented on a commercial scale in Greenland, what's to say that it couldn't be implemented in other hostile climates such as Mongolia, Nigeria, the Sudan, Antarctica, or even on the moon?

Works Cited

Andersen, Signe May. "Vitamins and Minerals in the traditional Greenland diet." *National Environmental Research Institute,* NERI Technical Report No.528, 2005, p.11, https://www2.dmu.dk/1_viden/2_publikationer/3_fagrapporter/rapporter/fr528.pdf. Accessed 28 Jul. 2019.

"Aquaponics in the World." *Thorilex*, 9 Nov. 2017, thorilex.com/aquaponics-in-the-world/. Accessed 3 Mar. 2019.

"Commercial Aquaponic Systems from Nelson and Pade. Earn profits from aquaponic farming." *Nelson & Pade Aquaponics,* https://aquaponics.com/aquaponic-systems/commercial-systems-3/. Accessed 9 Mar. 2019.

"Child Hunger in Greenland." *The Borgen Project*, 24 Nov. 2017, borgenproject.org/child-hunger-in-greenland-2/. Accessed 28 Feb. 2019.

"Data.org." *Climate,* en.climate-data.org/north-america/united-states-of-america/michigan/greenland-132922/. Accessed 27 July 2019.

"Economy and Industry in Greenland." *Til Forsiden,* naalakkersuisut.gl/en/About-government-of-greenland/About-Greenland/Economy-and-Industry-in-Greenland. Accessed 3 Mar. 2019.

"Fish Species Suitable for Aquaponics System." *Regenerative,* https://www.regenerative.com/magazine/fish-species-suitable-aquaponics. Accessed 28 Jul. 2019.

"Greenland Population (LIVE)." *United Arab Emirates Population (2018) - Worldometers*, www.worldometers.info/world-population/greenland-population/. Accessed 19 Feb. 2019.

"Hydroponic Systems 101." *Germinating Seeds | A Guide on How to Germinate a Seed*, www.fullbloomhydroponics.net/hydroponic-systems-101/. Accessed 1 Mar. 2019.

Menzel, Peter, and Faith D'Aluisio. *Hungry Planet: What the World Eats*. Material World Books, 2007.

"Overview." *USDA ERS - International Consumer and Food Industry Trends*, www.ers.usda.gov/topics/international-markets-us-trade/international-consumer-and-food-industry-trends/. Accessed 6 Aug. 2019.

Pedersen, Traci. “Greenland: Earth's Biggest Island.” *LiveScience*, Purch, 31 Jan. 2018, www.livescience.com/61602-greenland-facts.html. Accessed 19 Feb. 2019.

Solly, Meilan. “Greenland Lost 12.5 Billion Tons of Ice in a Single Day.” *Smithsonian.com*, Smithsonian Institution, 5 Aug. 2019, www.smithsonianmag.com/smart-news/greenland-lost-record-breaking-125-billion-tons-ice-single-day-180972808/. Accessed 6 Aug. 2019.

“The World Factbook: Greenland.” *Central Intelligence Agency*, Central Intelligence Agency, 1 Feb. 2018, www.cia.gov/library/publications/the-world-factbook/geos/gl.html. Accessed 5 Mar. 2019.

The Tundra Biome, ucmp.berkeley.edu/exhibits/biomes/tundra.php. Accessed 28 Jul. 2019.