Sustainable Horticulture Production in Greenland

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Introduction.

Greenland is an island in the northern hemisphere between the Arctic and North Atlantic oceans, totaling 2,166,086 square kilometers in area (U.S. CIA, 2009). As much as 1,755,637 square kilometers of Greenland are under massive ice sheets, while the remaining twenty percent of the island, primarily along the coastlines, is ice-free. Elevations range from sea level to 3700 meters. Greenland's climate ranges from arctic to sub-arctic, with permafrost throughout the northern two thirds of the island. Most of the forty-four thousand kilometers of coastline is mountainous and inhospitable, with the majority of the few settlements and cities situated along the western coast. This island has little arable land (U.S. CIA, 2009).

Most of the population (88%) is made up of Greenlanders, a category including both Inuit and native-born whites, with the remaining 12% being Danish in ethnicity (U.S. CIA, 2009). The primary population centers, including the capital of Nuuk, lie along the western coast of Greenland (U.S. CIA, 2009). The total population of this country is estimated to be about 57,500, as of 2008 (U.S. CIA, 2009). Life expectancy at birth for males is currently 66.8 years, and 72.3 years for women (U.S. CIA, 2009). The primary official language is Greenlandic, though Danish and English are also recognized (U.S. CIA, 2009). Greenland had an estimated 100% literacy rate in 2001 (U.S. CIA, 2009). June 21 is the national holiday, the longest day of the year (U.S. CIA, 2009).

The government of Greenland since 1953 has been a parliamentary democracy within the constitutional monarchy of Denmark, although steps are being taken in 2009 to further Greenland's independence from Denmark in terms of international status and foreign affairs (U.S. CIA, 2009). Prior to Danish influence and colonization in the 18th century, Icelandic Vikings named and inhabited the island from the 10th to the 15th century (U.S. CIA, 2009). Greenland is currently divided into 18 municipalities in three districts, and spans four time zones (U.S. CIA, 2009). There are no roads between towns, and transportation is limited to air or sea travel (U.S. CIA, 2009).

The majority of Greenland's economy is centered on mineral resources and the fishing industry (U.S. CIA, 2009). Various prawns constitute the major proportion of total exports from the country, with cod (*Gadus* spp.) as another significant resource (U.S. CIA, 2009). Greenland also gets substantial economic subsidies from the Danish government (U.S. CIA, 2009).

Greenland is one of few nations expected to profit substantially from global warming, due to increased arable land area and longer growing seasons (Traufetter, 2009). Receding ice fields are increasing pasture land and in very recent years animal husbandry has expanded from exclusively sheep (*Ovis aries*) and caribou (*Rangifer tarandus*), to now include a small number of dairy and meat cattle (*Bos* spp.) (Traufetter, 2009).

Sustainability.

Since the horticultural movement in Greenland is still in its infancy, there is very little public dialogue regarding sustainability and organics, and it has certainly not been clarified on a nationwide level. However, although the word 'sustainable' has not been defined by any nationwide organization, it can be argued that the concept has a local connotation reflecting the

need to center production around natural sources of renewable, or continuous energy, in such forms as thermal vents and solar energy.

Greenland has some unique properties that can be taken advantage of, when designing a modern greenhouse structure. Steam and very hot water commonly issue from natural vents in many areas of the country, and can be utilized as free heating to growing facilities (Egedesvej, 2009). In addition, the extreme latitudes afford very long periods of sunlight during the growing season and solar panels can capitalize on the twenty hour days of midsummer (Egedesvej, 2009). This fact allows for abundant and inexpensive energy capture for greenhouse operations, after initial investment costs in the solar panels (Egedesvej, 2009). The very few greenhouses now in use followed the examples set by Iceland, utilizing natural heating and extensive daylight (Egedesvej, 2009).

Horticulture is quite literally a new trend in Greenland. There are brand new developments in the dawning industry. An initiative called the "Solar Greenhouse Pilot Project," under the direction of Bent Olesen, has been the primary, if not exclusive, movement in Greenland toward sustainable practices for the arctic environment of Greenland (Egedesvej, 2009). Bent Olesen, of the establishment called "Narsaq Greenhouse," was the representative from Greenland at the founding of the Nordic/Arctic Agricultural Association in 2005, and he constructed the first greenhouses in Greenland as recently as 2006 (Egedesvej, 2009). The goals and priorities laid out for the Pilot Project in Narsaq are those that would be typically associated with agricultural sustainability. Some of the goals include demonstrating the savings to be realized by local production, creating a substantial extension to the growing season, setting a standardized model to be used throughout Greenland, to stimulate economy, and to utilize alternative energy sources available in the Arctic (Egedesvej, 2009).

Two other agenda issues are mentioned on the Pilot Program's website. The first is the generation of new tourism, which is expected to increase with greenhouse tours and arctic research as the foci. As the program's website states, tourists will travel to Greenland "to see innovative uses of environmentally friendly technologies to grow fruit and vegetables in the Arctic."

The other issue of significance is the recent political struggle by Greenland for increased independence from Denmark, and the Pilot Program's political ambitions argue for increased national autonomy and self-sufficiency to be fostered through successful modeling and increased development of greenhouses on the island.

Interestingly, though mention is made of greenhouses being constructed to withstand high winds and destructive weather, wind energy seems not to be mentioned in any of the literature.

Historical Production.

Greenland was settled independently by the Inuit, and again by the Norse Vikings (Carlson, 2006). In the 10th century Eric the Red colonized and named Greenland, and is commonly reputed to have named the island 'green' so as to entice more colonists, but recent analysis of ice cores taken from Greenland's ice sheets, in conjunction with accepted historical climates, would indicate that Greenland's southern coast may well have actually been warmer and greener than currently existing conditions (Traufetter, 2009). This period of Viking inhabitance continued for five centuries, with apparent relative success based on numerous remains of farm houses and other structures, and records of herds of cattle on the island (Traufetter, 2009). However, during the early fifteenth century a mini-ice age fell upon Greenland, which may have been responsible for starving and wiping out the Norse colonists (Traufetter, 2009). In 1731, Danish missionaries

headed to Greenland with the intent to convert the rumored Greenlandic Norsemen, but found only native Inuit left on the island (Traufetter, 2009). This Danish contact with Greenland's natives eventually developed into what is now the Greenlandic people and language, a synthesis of its Inuit and Danish components (Lundberg, 1999).

Hunting and gathering for subsistence has historically been and still is a major method of acquiring food, even up to the present day (Caulfield, 1993). Wild plants commonly gathered are primarily limited to *Angelica,* arctic fernweed (*Pedicularis arctica),* hairy fernweed (*Pedicularis hirsuta*), mountain sorrel (*Oxyria digyna*), willow (*Salix* spp.), roseroot (*Rhodiola rosea*), seaweeds, crowberry (*Empetrum* spp.), bilberry (*Vaccinium* spp.), and mountain cranberry (*Vaccinium vitis-idaea*) (Porsild). In addition to these few plants traditionally used as nourishment, the partly digested and fermented rumen, mostly lichen, from the stomachs of muskoxen (*Ovibos moschatus*) and caribou are eaten regularly, as well as the vegetative crop contents of the ptarmigan (*Lagopus muta* Porsild). Major meat sources include seal, muskoxen, sheep, caribou, cod, and prawn (Porsild).

Current Production.

As mentioned, horticultural production has only recently been experimented with on the island. Some Greenlanders, primarily potato (*Solanum tuberosum*) and turnip (*Brassica rapa*) farmers, had been able to farm those crops outdoors to a limited extent, but environmental temperature and weather restrictions made most other crops unfeasible for production (Traufetter, 2009). Success stories from the current greenhouse operation at the Pilot Project include the production and sale of fresh tomatoes (*Solanum lycopersicum*) and cucumbers (*Cucumis sativus*) to local markets, where fresh produce has never really been offered (Egedesvej, 2009). For the first time

citizens are purchasing the highest nutritive and most flavorful vegetables to ever be offered in the country (Egedesvej, 2009). The greenhouse at the Pilot Project has even incorporated a banana tree (*Musa* spp.), a practice common in Icelandic greenhouses (Egedesvej, 2009). Egedesvej did acknowledge that the banana tree is expensive, and that the exercise was done primarily for the sake of curiosity and publicity, but it does provide fresh bananas in an arctic location that has never experienced such a thing (Egedesvej, 2009). The Pilot Project can be considered state-of-the-art, not only by Greenland's scant greenhouse standards, but also by modern convention in the greenhouse industry. Such modern solar panels, utilized in an arctic location with seasonally plentiful sunlight, boast a 20% energy capture rate compared to the 9-13% energy capture rate typical of conventional solar panels (Egedesvej, 2009). The structure itself, while specifications were unavailable, appears visually to be top of the line, in terms of modern materials, design, and construction. However, this project is only the very beginning of what may be a future trend. It must be stressed that the advent of greenhouses in Greenland is so recent that there is currently no existing data or assessments regarding the subject at all. Time will tell just how effective greenhouses can be in such an environment. In addition, climatic changes will presumably increase the availability of arable land as well as the growing season, which has been extended by almost a month over the last fifteen years (Traufetter, 2009). The growing season is currently comparable to that of the Alps at 1500 meters (Traufetter, 2009). Since the mid 1990s, average temperatures have increased by over 2 degrees C and, instead of the typical harvest of ten tons of potatoes per hectare in the mid-nineties, growers are now harvesting closer to fifty percent more kilos of root vegetables per hectare (Traufetter, 2009). Estimations are that if the growing season were to begin two more weeks earlier, farmers would

then be able to begin outdoor apple (*Malus domestica*) and strawberry (*Fragaria* spp.) production (Traufetter, 2009).

Production Recommendations.

Recommendations and considerations for improved sustainable practices to be implemented in Greenland should be centered primarily on the continued development and expansion of indoor growing facilities and programs such as the Pilot Project in Narsaq which can take advantage of plentiful and inexpensive geothermal resources of the region, in such a way that improves overall food supply within the country. With the long summer days of the northern latitudes providing light by which to grow, and an abundance of thermal and solar energy, indoor growers could conceivably develop sustainable and large scale production to serve customers locally within the region and country. This movement toward improved and sustainable food acquisition could have dramatic implications for Greenland. If the nation actively seeks furtherance of their growing facilities and infrastructure for growing fresh food, Greenland would likely enjoy many benefits, some of which include vastly reduced importation costs, a healthier overall population, and greater national independence and self-reliance within the global community. Although this optimistic outlook on the subject of food production is developing, few significant numbers for recent production have yet been reported for Greenland's infant horticultural industry, likely due to the extremely low volume of crops ever produced on the island. As such, I would expect the first greenhouse crops to include those pioneered at the Narsaq greenhouse, such as tomatoes and cucumbers. These horticultural crops are recognizable and familiar to most who purchase imported vegetables at a market, but the locally grown ones should reflect the freshness of a short transport and storage life that they enjoy when grown locally. They are also crops that can

bring in money to the entrepreneur who makes the commitment to grow them. The first field crops for increased production and regional research would likely be potatoes, followed by turnips. Both of these root vegetables have been cultivated to a higher degree in Greenland than anything else, though this is admittedly not saying much. If climatic trends continue as they are projected to, Greenland's future root crop production should increase, and scores of other crops should enter into the realm of possibility for indoor production. Though there is evidence of significant plans for agricultural and horticultural expansion after the introductory success of the 2006 development of the Pilot Project at Narsaq, the reality is that the current number of greenhouses in Greenland can likely be counted on the fingers of one hand. All the farmers in the country are likely to know one another by name or reputation, and there is evidently only one domestic commercial greenhouse grower of anything other than root vegetables. There is a long way to go before many crops can be grown at any significant level, though the promise of the improving climate and growing conditions combined with the advent of technologically modern growing facilities is very hopeful for the prospects of growing in Greenland. Additional factors favoring modern production in Greenland are the abundance of sheep manure for fertility, and the unusual absence of plant pests and pathogens in the arctic environment due to geographic isolation and a harsh environment (Egedesvej, 2009).

Sustainable Development Strategy.

Many options for horticultural expansion are available for exploration and research, and I expect a wide variety of approaches to develop as the economic and social benefits start becoming more enticing. Such developments will include building full-scale enclosed greenhouses, energy capturing of solar and geothermal resources, the cultivation of newly arable land in receding

glacial areas, a widening of available crop varieties as climatic temperatures rise over time, and others. It would be in the nation's interests to encourage the building and operating of greenhouses for commercial scale production, utilizing the abundant summer sunlight for plant growth and heating energy, in addition to the heating potential made available by regionally available geothermal vents. As such, I would recommend the development of legislation and policies through lawmakers for initial subsidies and grants to be made available to growers and business owners. This will help to generate Greenlandic farmers' interests, as well as bolster their production capabilities for growing food for local sale and consumption that will be unprecedented in the history of Greenlandic culture. In imitating the successful Pilot Project, sustainability and profitability should go hand in hand. Energy savings through the utilization of solar and geothermal sources will translate to greater profits, productivity, and food availability in Greenland's economy and culture.

Future Production Facilities.

Based on the identified need for improved infrastructure and development of facilities for horticultural production, the wisest first step is to establish goals for increased numbers of greenhouses throughout Greenland, and begin development by replicating and expanding the most recent success, the Pilot Project at Narsaq. The first of such greenhouses should be located both near a site of geothermal activity, to be utilized as a crucial yet inexpensive heating system for the greenhouse, and near a significant population center for ease of distribution, publicity, and resource acquisition. Since trees aren't common in the country, sunlight should be abundant nearly anywhere the greenhouse is positioned, whether inland or near the coast. As such, solar panels can be implemented in conjunction with the building to capture sunlight through the long

days of the summer. The sun's energy can be stored in batteries, or as thermal heat when necessary within the greenhouse itself. Some locations in proximity to glaciers or ice fields may actually benefit from increased solar irradiance due to high levels of reflection by the surrounding snow and ice, and may also provide water sources for irrigation options. Surplus captured solar energy can be stored and later utilized to vastly reduce costs of supplemental lighting for days of cloudy or inclement weather, and to run anything else associated with automation or function of the facility. This facility should initially focus on growing recognizable and somewhat common products to be sold locally, to improve food availability and build local acceptance and readiness to buy future products from the facility. Tomatoes and cucumbers can be vibrant and recognizable options that may have very noticeable flavor and texture if grown and sold fresh and local, and research into the feasibility of growing these crops in the proposed facility through analysis and comparison of the Narsaq greenhouse would be well advised. Production schedules could start with germination in March or April, or as soon as sunlight is reaching a reasonable day-length for solar panels to do their collecting. These crops could be grown in the successive two months, up until their growth habits and fruit production become marginal, at which point they can be succeeded by a second planting before the autumn day-length fades to the dark winter hours. I expect that pest problems will be virtually nonexistent, as mentioned earlier, and the only consideration I have identified as potentially problematic for these suggested commercial crops is the Tobacco Mosaic Virus (TMV), which could damage production unless worker hand-sanitation is addressed. The virus can be transmitted manually from anyone who smokes any commonly imported tobacco, so this pathogen will not be subject to the typical climatic or insect vector constraints that other pathogens must deal with, since cigarettes and smoking tobacco are transported easily and

frequently to any country. Simple hand sanitation practices should render this concern negligible. If production commercially accepted vegetables is successful, I see many benefits to duplicating the experiment with other investments in greenhouses, to bolster and further diversify Greenland's domestic horticultural industry and the offered products that will benefit the health, economy, and independence of individuals, businesses, and the nation itself.

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