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Could Singapore's Verticulture Hold the Key to Improving Food Security Around the World?

How could a country about the size of Chicago rank second to the United States of America in food security? Could its techniques help other countries around the world as a model for food security? Singapore's technique of producing food in small manageable spaces, or verticulture, is the key to its food security. Singapore is a relatively new country after it gained its independence from Japan in 1959. Over the years, Singapore has urbanized its tiny island nation and this has created huge problems. Since Singapore is only 277.3 square miles and has only 250 acres of farmable land, it imports 93% of all its food, which leaves the country with a great amount of debt. However, a Singaporean inventor named Jack Ng may have found an answer to this problem as well as the world's problems of space and food security.

Singapore only has 250 acres of land on which to grow its crops and with limited spaces Singapore needed to find a solution. In the 1950's the idea of vertical farming sprouted. A Singaporean inventor named Jack Ng heard about this idea and sprung at the opportunity to use it. He came up with his idea in the early stages of vertical farming research and implementation and he later patented ideas within his system he later called Sky Greens. A typical "A" frame Sky Greens structure consists of a nine meter high frame, thirty eight growing trays, uniform sunlight, irrigation and a nutrient rich tub at points in the rotation, and a water gravity wheel that rotates the trays. In the design the water gravity wheel rotates the trays, so that they have time at the top of the "A" frame where they get sunlight and at the bottom where plants pass through the nutrient rich tub to get water. They also have a sprinkler system to mist the plants periodically. Overall the design aims to have high yields, high quality of food, high flexibility, low energy use, low water use, and low maintenance. The farm's first prototype was built in 2009 and since 2012 the fully operating farm has been supplying the city's supermarkets with weekly deliveries of its greens.¹ Over the past few years, Jack Ng has been expanding his farms all over Singapore in hopes that this could make the country less dependent on other countries for food and in turn lower Singapore's debt. By doing this, Ng can help make Singapore a model for success in food security.

You may ask how affordable and successful these Sky Greens vertical farms are and if they could be implemented in other space deprived countries and cities. The answer is yes. The main cost of the farms is in financing construction and purchasing seeds. Once the structure becomes profitable, more units can be built. According to Ng, the energy needed to power one A-frame is the equivalent of illuminating just one 60-watt light bulb. In Singapore, that works out to only three dollars a month to run each 'A' frame vertical farm. The small amount of energy and water needed to grow the vegetables and the close proximity to the consumer means that CO₂ emitted in production and transportation is kept to a minimum.² The major climate concern with traditional farming is trace gasses (primarily carbon dioxide) in the earth's atmosphere alter its thermal properties, causing it to retain heat.³ Vertical farming virtually eliminates these concerns.

With Jack Ng's design he plans to expand his company Sky Greens to two thousand units and hopes his productivity would increase to supply Singapore with 50% of the food all Singaporeans will consume.

¹ "CNN.com" *Urban Farming Looking up in Singapore*. N.p., 9 December 2012. Web. 20 July 2015.

² "CNN.com" *Urban Farming Looking up in Singapore*. N.p., 9 December 2012. Web. 20 July 2015.

³ "SkepticalScience.com" *CO₂ Problems: Parallel Concerns Breed Parallel Denial*. N.p., 13 November 2011. Web. 20 July 2015.

With the population predicted to be about nine billion worldwide by 2050, we should begin to implement these vertical farms elsewhere in the world. Other countries such as those located in the southwestern region of Africa where land is not very arable, can use these techniques to gain food security and provide jobs to locals while also being energy efficient.

Singapore has also been looking into larger vertical farms such as those thought up of by JAPA, which is a Barcelona based architecture firm, called F.R.A or Floating Responsive Agriculture. These towers designed by JAPA are aimed at increasing the size of vertical farms already in Singapore by tenfold. In their design they want the buildings to have a loop shape so they maximize sunlight and float on the harbor to maximize the space in Singapore. F.R.A is a concept to consider. The architects hope to collaborate with the government in Singapore—along with local technology companies and food-related organizations—to keep pursuing it. "A set of prototypes on a smaller scale could be an interesting starting point," says Ponce. The designers are currently researching how much energy the system would require and how much food it might be able to produce.⁴

The typical farm family in Singapore usually consist of two parents along with two to three kids. In a typical farm, they own anywhere from one to twenty acres, so having a lot of kids to work the farms are not needed. Even though Singapore must import over 93% of all the food they consume, the diet of Singaporeans is bountiful. The average meals in Singapore consist of: rice, noodles, beef, vegetables, seafood, spices, and more. This may seem like a plus side for the people of Singapore but it brings a great deal of debt to the country. Singapore spends most of its money on importing rice, beef, and other specialty foods. Singapore's government is effected greatly by having to import all its food. Singapore recorded a Government Debt to GDP of 99.30 percent of the country's Gross Domestic Product in 2014. Government Debt to GDP in Singapore averaged 88.92 percent from 1993 until 2014, reaching an all-time high of 106.20 percent in 2012.⁵ Singapore has to stop its reliance on other countries for food products and focus on implementing ways to maximize its productivity and use of space.

In Singapore children's educations are taken very seriously and it came up with an effective and intricate system that consists of primary, secondary, and post-secondary school. For more than a decade, Singapore, along with South Korea, Taiwan, Japan, Shanghai, Hong Kong and Finland, has been at or near the top of international leagues tables that measure children's ability in reading, math, and science. This has led to a considerable sense of achievement in Finland and East Asia and endless hand-wringing and head-scratching in the West.⁶ With rigorous courses that are highly scripted and planned out, more than one hundred fifty million dollars are spent on education systems and research in Singapore. In Singapore the students are pushed to do their best because their performance will determine what type of school they would attend in the next stage of education.

Singapore is known around the world for having amazing health due to a low infant mortality rate as well as a high life expectancy. Singapore has become a model for its health care with over 75% of all citizens having health care. However, despite being a model for success in health care and education, Singapore's real problems exist in its agricultural farms and systems along with its government. Singapore is forced to import more the 93% of its food and this causes a huge financial burden. Now Singapore has to focus its

⁴ "Fastcoexist.com" *These Floating Vertical Farms Are Designed To Bring Local Food to the Densest Urban Areas*. Adele Peters, 29 July 2014. Web. 20 July 2015.

⁵ "TradingEconomics.com" *Singapore Government Debt to GDP*. N.p., 15 August 2014. Web. 20 July 2015.

⁶ "TheConversation.com" *Why is Singapore's school system so successful, and is it a model for the West?* N.p. 11 February 2014. Web. 21 July 2015

money and time on the expansion and marketing of these vertical farms, so it can decrease its dependence on other countries.

In Singapore the unemployment rate is at only 1.9% and in a survey done by the Department of Statistics' annual Key Household Income Trends, Singapore had an increase in household income of over two thousand dollars. Perhaps this decrease in unemployment and rise in household income come from the fact that these vertical farms are supplying more food to the country. With more of these vertical farms being built it can supply more jobs for the people. If Singapore's government would take advantage of working with Sky Greens to market the idea, it could help food security and employment rates in other countries by building them there and helping train the locals to run the vertical farms.

In Singapore, food arrives at shipping yards and The Central Wholesale Markets by hundreds of trucks coming from neighboring countries such as Vietnam and Indonesia and flown in from as far away as Denmark and Uruguay. Overall, Singapore has over 20 countries that import food to them.⁷ From there, it is loaded onto smaller trucks and they take those shipments to local markets and grocery stores. In Singapore, having food grown in the country is a luxury, but by increasing its productivity with vertical farms it can make this luxury accessible to more people while decreasing costs.

The major barriers to creating better food productivity can be overcome by using vertical farming or "verticulture" and other urban farming techniques. The topic of food security has also begun to appear at local universities. Melissa Reese, journalist, stated "I recently sat in on an architecture studio at NUS (National University of Singapore) which designed solutions for Singapore to grow enough food to support the basic nutritional needs of the entire population for one year if there was a food crisis."⁸ If they were to create more of these farms they could supply more jobs to Singapore and decrease their dependence on other countries for food as well as become a model for other countries on how to be food secure.

What is sustainable agriculture? Sustainable agriculture is the production of food, fiber, or other plant or animal products using farming techniques that protect the environment, public health, human communities, and animal welfare.⁹ Singapore was faced with the issue of space and with this it turned to vertical farming in order to try and fix its problems and become a model of food security for the world. By expanding its farms, Singapore hopes to decrease dependence on other countries for food since over 93% is being imported today. As Singapore looks to vertical farming as a solution, it is the pioneer of the science since Sky Greens was the first commercial vertical farm. Also they could use this idea to help out neighboring countries as well as others to fix arable land problems, space issues, and food security issues.

If Singapore had not turned to these techniques of farming, it would be drowned in debt within the century and become poverty stricken. By creating these techniques of urban farming and expanding on them, Singapore is improving its financial state by slowly decreasing its dependence on other countries for food by increasing the domestic agricultural productivity.

Right now Singapore is producing only 7% of its food and imports the rest. This creates a severe situation and if it cannot increase this percentage, Singapore may be facing even more debt. Since Sky Greens is newly perfected after 50 years of prototyping and research, the years to come could show more growth.

⁷ "Asiaone.com/youthhealth" *Where does Singapore source its food from?* Anupa Ghosh. 29 April 2013. Web. 21 July 2015

⁸ "EncounteringUrbanization.wordpress.com" *Food in Singapore: Everywhere but Nowhere.* Mel Reese. 3 December 2011. Web. 21 July 2015

⁹ "SustainableTable.org" *Sustainable Agriculture – the Basics.* N.p., n.d. Web. 21 July 2015

The company plans on expanding to over two thousand units in the next few decades which could help Singapore produce 50% of the food it consumes. As stated in previous paragraphs could the decrease in the dependence of other countries for food in the last five years have led to the increase in the average household income? If so, this could mean that the average household income could also increase for families in Singapore over the next five years.

The trend of vertical farming in Singapore is improving and increasing because Singapore realizes it has to decrease its dependence on other countries for its food and one of the ways it has been doing that is vertical farming because it maximizes space, increases productivity, decreases dependence on other countries which in turn lowers debt, and it is energy efficient. This trend can be measured by the amount of food produced in Singapore in relation to the amount of food it has to import into the country. For example, right now it is 7% domestic plant production and 93% imported foods. These measurements show that Singapore is trying to become less reliant on others for food and want to produce its own to save money, energy, and it would keep the environment clean from pollutants that all the shipping would produce. Sky Greens vertical farms are the first low carbon hydraulic water-driven vertical system in the world to grow tropical-vegetables vertically in Singapore, which gives significant yield and uses less water, energy and natural resources, to achieve a sustainable green high-tech farm.¹⁰ Since these are energy efficient, they can be implemented in other third world countries and still have a low cost for running them. Also, they can create a profit from one so that another may be built and then after a while you could go from one to one hundred just by using your profits to build more. With these farms being energy efficient and good for the environment, they can lower the prices of the food they produce at the supermarkets. This is due to the fact that there is less money going into shipping costs to help turn a profit so the cost can be lower.

Major issues in the world such as: population growth, energy demand, and urbanization can be addressed with these vertical farms. With either JAPA's design that incorporates the huge loop shape and is designed to be on the harbors of Singapore or Sky Greens design, each of these vertical farming techniques can address the problems stated above. The current world population of 7.2 billion is projected to increase by 1 billion over the next 12 years and reach 9.6 billion by 2050, according to a United Nations.¹¹ With the world's population growing to 9.6 billion in the next 35 years we will need space to house people and more food to feed people with less space. By using vertical farms you can maximize space and produce a lot more food within less acreage while using less energy and less water. For the growing population issue it would be better to use JAPA plans called F.R.A or Floating Responsive Agriculture. With this design, it can conveniently be located on harbors, so it does not take up valuable land space. With this design it creates large amounts of food. The loop shape, along with its rotation system, maximizes sunlight and uses less water than conventional farming methods. For the issue of energy demand, the Sky Greens design runs for only three dollars a month which is equivalent to running a 60 watt light bulb. By being energy efficient, this allows countries with little money and electricity to produce its own food. With the Sky Greens design, it allows plants to grow in environments where conventional farming would not be as successful. Finally, urbanization is the next problem facing agriculture. By 2030, it is expected that 60% of the world population will live in urban areas. Almost 180,000 people are added to the urban population each day.¹² Singapore is no stranger to urbanization.

¹⁰ "Premaculturenews.com" *Vertical Farming: Singapore's Solution to Feed the Local Urban Population*. Ravindra Krishnamurthy, 25 July 2014. Web. 21 July 2015

¹¹ "UnitedNations.org" *World Population Projected to hit 9.6 billion by 2050*. N.p., 13 June 2013. Web. 21 July 2015

¹² "UnitedNations.org" *Urbanization: Facts and Figures*. N.p., 6 June 2001. Web. 21 July 2015

After it became an independent country in 1959, Singapore began urbanizing. Deforestation caused the loss of 90% of its forests. By 1990 the government took action by saying that the last 10% of the original forests would stay untouched and from there it continued with the land it had and built a marvelous city. However, all of this came at a price. Since Singapore urbanized on most of its land, it was left with very little for farming and began to have to import food. This cost the government immense amounts of money and began to increase debt. For Singapore as well as other cities, implementing vertical farming within close proximity to the cities could produce large amounts for food for the people while also cutting back on pollution from transportation because it would not have to be shipped from such a far distance. Also, these vertical farms could supply jobs to people in the urban areas, thus decreasing the unemployment rate in that city.

To fix the problems in Singapore so that it can become a model for food security to the rest of the world, we will need the cooperation of the Singaporean government, civil engineers, as well as agricultural and biological engineers, marketing experts, JAPA, Sky Greens CEO Jack Ng, and the people of Singapore. Through the expansion of the Sky Greens Company throughout Singapore so it can become less dependent on other countries for food. By having more food grown in Singapore it will save on shipping expenses, prices of food will go down, less trucks will pollute the air, and more vertical farms mean more jobs. This strategy can also be implemented in other countries with food security problems like Cambodia or countries with very little arable land like Botswana. By doing this in other countries, it also helps create more jobs, create more food, maximize space, and grow the Sky Greens Company making this a win, win situation. That leads me into the next part about my plan of expanding and marketing Jack Ng's idea of the Sky Greens vertical farms. By using marketing and Singapore's government to work with other countries it can then spread its company internationally and in turn help millions and even billions of people have food security or access to local greens and adequate nutrition. As for the Singaporean citizens, they can start on local projects such as starting personal vertical farms for their families or even roof top gardens so they could contribute to the percentage of food they consume as a nation. In the final steps of my plan, I hope to adopt JAPA's concepts a reality, or at least start the process because now they are only working on drawings and have yet to start on prototypes and miniature models. By starting the JAPA project, it can generate tons of food not only for Singapore but for other cities if the design is successful.

The Singaporean government should work alongside with JAPA and Sky Greens to expand its companies and work on constructing more Sky Greens vertical farms in Singapore as well as starting construction of the JAPA project so they can maximize locally grown food with this unique and large design. If all goes well in Singapore with the JAPA design, it too can be spread throughout the world to decrease food security issues, lower unemployment rates by supplying people with jobs, increase food production, and find a more energy efficient way to farm. On a smaller scale, the locals can create community urban gardens on their rooftops or balconies. On their balconies, the locals can have small vertical farms where they can grow their own leafy greens or herbs so they can add those into their meals. With the roof top gardens they can create larger vertical farms where they can grow other bigger vegetables like Chinese cabbage or bak choi and use those in the meals. By doing these little practices on a smaller scale it can help Singaporeans and everyone around the world. We will see Singapore as a model of food security that other countries can imitate to help them become more food secure.

Norman Borlaug once said, "Civilization as it is known today could not have evolved, nor can it survive, without an adequate food supply."¹³ With the world population growing to nearly 9.6 billion in the next thirty five years we will need to start thinking about creating more food with less space. By using Singapore as a model for food security after it has expanded its Sky Greens farms and decreased its

¹³ "BrainyQuote.com" *Norman Borlaug Quotes*. N.p., n.d. Web. 21 July 2015

dependence on other countries for food, it can then spread its ideas to other countries. Other countries can then maximize food production with limited space, save energy, lower unemployment rates by employing people to run the farms, and save money by not having to import as much food. Singapore's national motto is "Onward, Singapore." Maybe its new motto should be "Onward and Upward, Singapore" as they begin to grow skyward and become a model of food security for the world.

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