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China, Factor 6: Sustainable Agriculture

Hydroponics: The Easiest Way to Achieve Sustainable Agriculture in China

Background

Food is the foundation of people's lives. For years, people have been trying to find the most sustainable way of farming to increase yield while minimizing the damage to our environment. In a country that has a vast population, sustainable farming is even more important because it not only needs to support the current population, but also needs to take into account future population growth and the future of food production. China is an example of this situation. Currently, China has a population of an estimated 1.38 billion, which is about one-fifth of the world population (CIA World Factbook). In addition, they are experiencing a population growth of 0.41%, which makes the challenge of increasing food yield even more urgent. China has an overall land area of 9,325,410 square kilometers, but only 11.3% percent of it is arable land (CIA World Factbook).

Current Situation

China has experienced large growth in its agricultural production ever since the Green Revolution, especially after the invention of genetically modified rice by Longping Yuan. However, with the continued growth comes challenges to the environment. China is known as the largest producer and employer of pesticides in the world, producing more than 3.7 million tons of pesticides in 2014 (Statista). Limited use of pesticides can be beneficial by controlling the damage on crops by pests and increasing food yield to meet the needs of the population. However, when used in large amounts, it poses threats to water sources. When pesticides runoff the plants and enter the soil, the chemicals can enter the groundwater system, which affects humans by contaminating human drinking water sources.

China is also one of the world's largest users of fertilizer, using 52.7 million tons in 2013, which was 29% of the world's consumption (Heffer). Although fertilizers increase agricultural yields and food production, they can leave some negative environmental impacts. For instance, large use of fertilizer has proven to increase the surface runoff in many regions with high precipitation, which affects large bodies of water in regions where fertilizers are heavily used. Excessive use of fertilizer can lead to eutrophication in adjacent bodies of water, due to the presence of large amounts of nitrogen and phosphorous compounds in industrial fertilizer, killing hundreds of thousands of fish population due to the lack of oxygen. The decline of fish populations will eventually lead to a decrease in the local fishing industry and a reduction of an important source of food protein.

Additionally, farmers in some regions of China have expressed concerns about uncertainties in weather patterns in China. In an interview with a farmer in the Northeastern part of China, he stated that "for whatever reason it is, weather is becoming more and more unstable, making harvests more difficult each year" (Li). Guotang Li, as a representative of many different farmers in his region, lives an ordinary life

throughout the year – spending most of his time on the land or in his home. During the spring and fall, he spends the majority of his time farming crops, but in the summer and winter, he spends the majority of his time in his home due to the extreme heat or cold (Li). As a result of those seasonal shifts, his productivity as a farmer is relatively low since he can only use half of an entire year to farm.

Soil Erosion and desertification are also large problems in China when it comes to sustainable farming, as between 2460 and 10,400 square kilometers of area are becoming desert every year. More than 27 percent of China's land is desert and this number is steadily increasing, resulting from overgrazing and soil degradation (CIA World Factbook). Although there are many consequences of soil erosion and desertification, the most important consequence that people must consider is the loss of farmland. China already has a small percentage of farmland, compared with other countries in the world and this number is still decreasing due to increased yearly soil erosion.

Problem

Due to the high use of pesticides, fertilizers and increased soil erosion and desertification, China is facing serious problems with water pollution and loss of arable land to grow enough food to support its vast population.

Proposal

The solution I propose to address the problems above is using commercial and domestic hydroponics, which can solve food insecurities by producing more food with less potential negative consequences.

Hydroponics is growing plants in nutrient-rich solutions without any soil. There are a number of different hydroponic systems, each having distinct benefits and drawbacks. However, there are two prominent types of hydroponic systems that can be implemented to address China's food insecurities, the first being a large scale nutrient film technique and the second being small scale hydroponics using an electric pump.

For both planting techniques, there are three components that are essential to the success of the system, light, temperature, and nutrient solutions. Although different plant species require different amounts of sunlight every day, sunlight is crucial in hydroponics systems. Temperature is another crucial component of hydroponics and it should be regulated between 70 to 80 degrees Fahrenheit during the day and 60 to 70 degrees Fahrenheit at night (Kessler). The nutrient solution is the most important part of a hydroponic system, but it is also the hardest component to maintain. Generally, there are two groups of nutrients that should be supplied by the solution, macronutrients and micronutrients. The five most important nutrients that should be supplied by the solution are nitrogen, phosphorous, potassium, calcium, and magnesium (Kessler).

In order to begin commercial hydroponics, companies in China will need to set up large scale production hydroponic farms in areas with abundant sunlight. A greenhouse works well with this scenario, where plants can be densely placed in a system where solutions are continuously pumped through the planted channels. Plants are immersed in the water solution during the entire growing season providing continuous nutrients. Since the water solution can be used repeatedly, the usage of water in commercial

hydroponics can be largely minimized, compared to conventional agriculture. The channels should be no longer than 10 to 15 meters while the solution should be pumped in the channels at an average speed of 1 liter per minute (Langenhoven). Since channels are recommended to be less than that length, many people build their systems vertically as it takes less space to do so. The main advantage in this system for commercial use is that it can quickly produce a large amount of food in a relatively small area. However, the start-up costs of the initial system can be expensive. Additionally, farmers need to pay close attention to the water quality (pH, nitrates, phosphates, etc.) in the nutrient solution.

As commercial hydroponics is largely different than conventional farming, the energy requirement is extremely different. For instance, in a study done in Yuma, Arizona on hydroponically produced lettuce, researchers discovered that yields of hydroponically produced lettuce could be 11 ± 1.7 larger than conventionally produced lettuce, in terms of weight (Barbosa). Although hydroponically produced lettuce also requires "82 ± 11 more energy per kilogram" of energy than conventional farming (Barbosa), the yield of hydroponic technique still makes it a suitable solution to solving the increasing need of food. Meanwhile, since the majority of energy used by hydroponic greenhouse is for heating and cooling, where the greenhouse is situated becomes extremely important. If the greenhouse is built in a natural temperature that is suitable for hydroponic farming, heating and cooling can both be largely reduced. Even if the citing of the greenhouse is not ideal, there are other more sustainable options in heating and cooling greenhouses, such as incorporating shade cloth, ventilation, and the use of evaporation on wet walls (Schiller).

There are many criteria to evaluate whether a new technology is suitable for a nation. For example, according to a paper done by Robert Wicklein of University of Georgia, there are seven criteria, including system-independence, image of modernity, and single-purpose/multi-purpose technology (Wicklein). Particularly for implementing commercial hydroponics in China, farmers can create system-independence and an image of modernity by creating an individual greenhouse unit, and make hydroponics serve more functions by incorporating aquaponics (the usage of fish and fish tanks as substitutes to the water channels).

An example of using hydroponic farms is Fancyleaf in Australia (Fancyleaf). They have been producing lettuce using hydroponics for over 20 years in Australia and they are one of the major suppliers of lettuce to the Brisbane Distribution Center for Australia's supermarkets. They have also aided in the development of hydroponics as a multi-million dollar industry in Australia (Fancyleaf). The success of this organization, although in another country, shows significant promise in long-term success in commercial hydroponic farms.

For home gardeners, a simple channel filled with substrates and an electronic pump can be set up easily to meet the needs of a household. Since hydroponic techniques can be used in different agricultural products, such as tomatoes, peppers, strawberries, as well as other leafy vegetables (Tognoni).

Everything that is needed for a simple hydroponic system is an electric pump, a few PVC tubes, a suitable substrate, nutrient solutions, and the plants themselves. A substrate is something that will hold the plant roots in the channel while leaving enough space for oxygen and for the solution to drain from the top to the bottom of the channel to be recycled (Kessler). A good substrate should also be free of diseases and

pathogens and should not be easily broken. Poor flow of water can lead to overflowing of the entire system or drying the roots, so arranging the amount of substrates is essential in building a home garden system. Examples of substrates include gravels, perlites, and rock wool.

In addition to the channel component, a container should hold the solution that flows out from the channel (Kessler). At the bottom of the container, there should be an electronic pump, connected with the top of the channel to ensure that water is pumped into the channel at the same rate that it is flowing out. That kind of system can be used in urban homes in China since it does not require much space. For example, many people set their system up vertically on their windowsills so that the plants can receive enough sunlight. Since the system is built vertically, food yield will increase drastically. In China, 57.9 percent of the entire population lives in urban areas, which makes this system even more essential to solve China's food challenges (CIA World Factbook).

Building large-scale commercial hydroponic farms and encouraging home gardening using hydroponics can increase food yields while decreasing the area needed to plant. Wide scale public acceptance of hydroponics can help alleviate food insecurities.

Conclusion

The main issue that China is facing is that due to the use of pesticides, fertilizers and soil erosion, people are polluting their water sources and losing a large amount of arable land. Additionally, farmers of certain regions in China need a sustainable solution to the increasing change in weather patterns. Both of these issues can be solved by using hydroponics in large-scale production and home gardening since hydroponics uses less water, compared with traditional farming and recycles the water it uses until it needs to be replaced. In addition, there is no use of pesticides and more precise use of fertilizers, which can diminish their effects on human drinking water sources and bodies of water. Meanwhile, using hydroponics can also alleviate the problem of losing arable land since hydroponics can be implemented on a large scale and in people's homes. With the same amount of land, hydroponics can produce more food since plants can be planted more densely.

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