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The People's Republic of China, Sustainable Agriculture

Natural and Mechanical Amalgamations

In 1996, The People's Republic of China proclaimed with conviction that the world's most populous country, 1.4 billion individuals, would achieve 95% self-sufficiency in grain production. Through considerable investments in agriculture, China has been able to produce its 261 million ton grain consumption with minimal imports (China Power, 2017). Despite this success, China still relies heavily on imported agricultural products. In 2014, China imported over 17 billion in vegetables from the United States, 80% of which were soybeans. Furthermore, the agricultural products grown in China are of poor quality due to the ineffective and unsustainable methods used. In order to produce quality, safe agricultural products at self-sufficient levels, China must consider new methods.

Within the 3.705 million square miles that comprise China lies 10% of the world's arable land (The Vertical Farm, 2011). This roughly translates to 0.19 acres (or 8276.4 square feet) per capita of cultivable land (China Power, 2017), 40% of the world average and 20% of the American average (SETAC, 2014). These patches of cultivation are found inland along the banks of the Yangtze and Yellow river basins. Historically these fields were periodically nourished by the bursting of the rivers from there banks, leaving behind the rich soils collected from further upstream. However, this prosperity came at a cost, as the resulting flooding has claimed thousands of lives over the years. In an attempt to remedy this issue the Chinese government created the Three Gorge Dam. Eight times bigger than the Hoover Dam along the Colorado River, this $24 billion dollar feat of civil engineering generates 18,000 megawatts of clean energy. This structure limits the amount of water flow and creates a massive lake on the upper side. This disrupted the natural processes of the flood plains however, causing the soil in the once rich valleys to become tired without replenishment (Scientific American, 2008). Every gust of wind blows more of this exhausted soil away, eroding this once thriving plain (Wild China, 2008).

In order to make these soils usable again, farmers have begun use disproportionate and catastrophic amounts of pesticides and nitrogen based fertilizers with the help of government subsidies to produce staples such as rice, corn, and wheat. At the turn of the century China started its campaign to support farmers within the country's borders. For centuries, agriculture was the primary form of employment for the population, making up 55.31% of the workforce in 1991 however, that number has plummeted to a mere 17.51% in 2017 (World Bank, 2017). The industry accounts for less than 8% of China's 12 trillion USD GDP. As China rapidly industrialized, the gap in quality of life between urban dwellers and rural citizens widen, rural incomes being a mere 30% of their average urban counterparts. Guided by the noble mission to raise the average rural income and boost the production of staples the government phased out its farm production tax, grazing tax, and encouraged the provinces of China to repeal other fees that targeted farmers. The Chinese government also began to provide subsidies to farmers directly and through the provinces. These take the shape of assistance when purchasing modern farm equipment or GMO seeds. The farmers are also provided with additional income, though the factors that decided the amount differ from province to province (USDA, 2005). Apart from increasing the amount of agrochemicals used, these subsides have also supported wider spread use of fuel guzzling trackers and genetically modified rice crops (Wild China, 2011).

This massive dumping of more than 200 kilograms (441 pounds) of fertilizer per acre is fifty times what farmers in the 1960s used on these same fields. China is responsible for 30% of the world's nitrogen use. Only 25% of the fertilizers actually reach the plants, this is the lowest fertilization efficiency in the world and is less than half as efficient as nitrogen use was in 1961 for China. What cannot be absorbed by the target plants is washed away into the water system or remains in the soil. Though 7% of this wasted nitrogen does end up fertilizing future crops (China Dialogue Ocean, 2018), the other 93% can, and often does, drastically change the PH level of the soil, leaving the already tired soil acidic or alkaline and inhospitable towards even the most resilient of genetically modified crops (The Vertical Farm, 2011). The excessive nitrogen has also created colossal dead zones off of China's coast and in one-third of China's freshwater lakes, including the five largest. The largest of these blooms have been in the Yellow Sea between 2013 and 2017, swallowing an area of 30,000 square kilometers (China Dialogue Ocean, 2018).

Pesticide use has also increased by 4.9% annually since 1991, swelling posthaste from the 0.79 million tons demanded in 1991 to the 1.8 million tons consumed in 2011. Though the application patterns of pesticides remains unchanged, concentrated most heavily in the southeast provinces, due to their economic prosperity and the high temperatures coupled with frequent rainfall that make the application of pesticides less efficient, which accounted for 61.7% of pesticide use in the Republic during 2009, the amount applied per hectare has more than tripled from 2.71 kg in 1996 to the 14.0 kg reported as the national average in 2009. The amount applied in the individual provinces varies widely however, ranging from the 64.3 kg/ha application dosage in Hainan to the 2.2 kg/ha application dosage found in Ningxia. The most commonly used pesticides are insecticides (around 40%), followed by herbicides (31%), fungicides (25%), acaricides (3%), and growth regulators (1%). Until the 1983 ban organochlorine insecticides, primarily DDT and HCH, were the most heavily used; Today 71% of the insecticides used are organophosphates, though similarly functioning carbamates are also highly used (4.8%) (SETAC, 2014). These insecticide groups function through binding to acetylcholinesterase, an enzyme that plays a critical role in neurotransmission in both insects and mammals (Environmental Health Perspective, 1990). Although these chemicals are effective in minimizing crop losses, there are costs. Organophosphate and carbamates end up in the environment and in our bodies. HCHs, DDTs, CBs, and organophosphates have all been found in concentrations ranging from 39.82–282 ng l^{-1}, 43.15–292 ng l^{-1}, 33.38–1064 ng l^{-1}, and 4.44–635 ng l^{-1} respectively in the 8000 sq. km Pearl River Delta (The Royal Society of Chemistry, 2002). 20,097 reported cases of pesticide poisoning were reported between the years of 2004 and 2010, 1,413 of which were fatal in the Zhejiang province alone (BMJ Open, 2013). Consequently, 95.8% of urban consumers and 94.5% of rural consumers voice concern over the quality and safety of agricultural products, factors both linked directly to residual pesticides on market products (Food and Agriculture Immunology, 2010).

The inefficacious drive to produce at quixotic and unsustainable levels on inadequate amounts of land can be blamed, partially, on the impression left by chairman Mao's Great Leap Forward and the resulting famine. In the 1958 the Chinese Communist Party declared the beginning of the Great Leap Forward movement. The new Communist Government set forth to surpass Great Britain's industrial production in 15 years and the United States within 30, despite the fact that China was an impoverished agrarian economy with virtually no industrial assets. In order to make this rapid industrialization possible, all investible surplus had to be collected from the largely rural and subsistence farming populous. The agricultural productivity had to grow from the small horticultural operations to large mechanized collectives. Over a period of five years (1953-58) agricultural operations morphed from family homesteads to voluntary cooperatives to government run People's Communes that incorporated thousands of households. Lulled into a false sense of security by the collectivization of the agriculture industry and the introduction of newer farming techniques (i.e. diesel fueled tractors and chemical fertilizer), the central government began to divert resources from food production to industrialization, removing 38 million individuals from the agricultural workforce. Those remaining on the communes were encouraged to allocate more land from grain cultivation to the production of cash crops and the construction and operation of iron furnaces. Inevitably, the diversion of labor reduced the amount of grain produced (by 15% in 1959) and due to a wasteful and urban favoring ration system, rural workers were forced to toil. Resulting in a 29% drop in average calorie intake. Without proper calories to support the physical labor involved in farming, the crops the following season suffered. Despite the government's best efforts to mitigate the damage, via shifting resources back to agriculture, grain product still dropped by an additional 16% over the following 2 years and 16.5 to 30 million people starved to death (Journal of Political Economy, 2005). The importance of agriculture has remained scarred into the countries collective minds, creating a sore spot when issues of underproduction and unsustainable practices come into the forefront of the political dialogue (Who Will Feed China?, 1995).

Population control is often the most considered response to underproduction. In 1957 Ma Yinchu, a demographer and economist, advocated for population control via promoting later marriages and readily available, effectively used contraceptives, warning that unchecked population growth would lower the standard quality of life in the country. These ideas went widely unacknowledged until the late 1970s when population growth became the forefront of political discussion after the population nearly doubled in a 29 year period. The Communist Party announced and began to enforce the family planning policy, or the one child policy, in 1979. This policy consisted of changing the legal age of marriage to 22 years of age for men and 20 for women and stern enforcement that couples only birth one child. Punishment for violation of this policy often included a financial penalty of 3 to 6 times each parents average income, difficulty when dealing with administration for entire families if a single member broke the policy, and in some extreme cases forced abortions. Rare exceptions to the policy were made if both parents were only children or if the first child was disabled. As a result of this policy, there are 40 million more men than women in the People's Republic, as there is a cultural president to have your sole heir be male rather than female, particularly in rural communities (Economic Affairs, 2014). Though this policy was partially justified by agriculture, the results benefit farming very little. The one child policy disrupted the family patterns and dynamics for most farmers. Sons were to work on the farm and daughters were to marry off, but now only having one heir the role of children has been altered.

The demographics and demands of the Chinese population are changing at a rapid rate. It is predicted that 60% of China's 1.4 billion people will live in urban areas by 2020 (China Power, 2017). These urban areas are responsible for a large amount of pollution, this is due to a combination of large amounts of cars (5 million in Beijing alone, that do not meet current UN emissions regulations), along with coal powered factories, and residents using coal burning stoves for heating and cooking. In Beijing, particles less than 2.5 microns in diameter that do extensive damage to human lungs (PM 2.5) was measured at unhealthy levels, ten times the maximum recommended by the World Health Organization, 49% of the time in 2015 (BBC, 2015). The average life expectancy is 76.34 years, though pollution related health problems have caused many urban dweller's lives to be shortened (Statistical Yearbook, 2016). This pollution does not remain in the air however, it becomes integrated into China's soil and water supply. This contamination of combustion particles and metals, along with the drenching of crops in pesticides, has left the crops produced in China unsafe for consumption; China is ranked 40th out of 113 countries for food quality and safety by the Global Food Security Index (China Power, 2017).

The issue of sustainable agriculture cannot be addressed without also addressing environmental destruction. China is home to over 30,000 higher plant species and 6,347 vertebrate species. This accounts for 10% of recorded plant species and 14% of recorded vertebrate species. As a result, China is eighth most biodiverse country in the world. However, this plethora of species is under threat. Between the years of 1970 and 2010, amphibian and reptile populations dropped by 97%; mammal populations fell by 50% overall, though mammals in particular habitats suffered more than others. The collapse of China's wildlife populations can be directly attributed to the loss of habitat caused by agriculture and urban growth (WWF Report, 2015). This destruction can only be amplified as China's demand for agricultural products is expected to increase 30-50% by 2035 (Environmental Toxicology and Chemistry, 2014); Coupled with the fact that the Republic's urban populations are growing at a rate of 8.47% (Global Change Biology, 2014).

A solution with the potential to address both of these issues is mass scale indoor farming in an urban setting. Being indoors would allow produce 10 to 20 times more for the same acreage as a traditional farm, simply by recusing inclimate weather based and pest based plant loss and creating optimal growing conditions (The Vertical Farm, 2011). Being able to produce more in the same acreage would allow for less land to subject to the abuses of farming and be returned to its original state, giving back the land in this way would help mitigate the damages done to China's magnificence wildlife and improve air quality. Urban locations allows the production of grains, vegetables, and fruits to be directly provided to the majority of consumers with very little food miles, this would drastically reduce the carbon footprint of nearly all of these goods.

The technology to create indoor vertical farms on a massive scale has existed for over a decade and is relatively simple. Aeroponic, the spraying of a nutrient solution onto the roots of a suspended plant, and hydroponic, the growing of a plant in a nutrient solution, systems would be the basis for cultivation, with the nutrient solution being tailored specifically to the plant species being cultivated in each block. Aeroponics are ideal for growing grains, herbs, and some verities of vegetables (i. e. simple tubers or leafy greens). Whereas hydroponics would be more effective in the growing of vegetables and fruits (i. e. legumes, fruit and nut trees, and leafy greens). These methods also use significantly less water than traditional irrigation, reducing the water used by 70-95%. As neither of these systems require pesticides the quality of the products is ensured. Although these buildings would have south facing windows to allow the maximum amount of natural light in, specialized LEDs that produce only the light waves required by plants to photosynthesize would also be used to maximize crop yields efficiently. These systems will be powered by solar panels or wind turbines in order to meet the environmental purpose of the structure. The building itself should be made of local, sustainable, and/or waste products. Its design should meet the highest environmental standards in way of water and energy consumption.

These structures would be grafted into the city's sewer systems to act as water purifiers, helping to create a waste free system. Plants, such as sunflowers and soybeans, would be grown hydroponically in greywater, water that has had some level of filtration but is still considered unfit for consumption. As these plants grow the transpiration released from the leaves would be collected. The collected water would be clean and could be used to irrigate crops being grown for consumption or pumped back into the water supply to be reused (The Vertical Farm, 2011). The plants used for filtration would not meet production standards but could be refined into biofuels to power any logistics. Since these biofuels would be produced as a byproduct and since the building itself is not fueled by coal, the biofuels produced in this way would be extraordinarily environmentally friendly.

The only thing in the way of accomplishing vertically grown fresh fruits, vegetables and a secure source of staple crops in a controlled environment is the will to make it happen. The Chinese government has spent hundreds of billions of dollars on cleaning up the city of Beijing alone (BCC, 2018) and spends billions more on farm subsidies for products that would be cheaper to import (SIPRI, 2016). If even a fraction of those resources was put towards developing and cultivating a vertical farm the societal benefits would be massive: renaturalization, food security, and a living filter.

Sources

1, 2. F. (2018, June 1). Algal blooms endangering China's seas. Retrieved July 9, 2018, from https://chinadialogueocean.net/2959-algal-blooms-are-starving-chinas-seas-of-oxygen/

Agriculture, forestry, and fishing, value added (% of GDP). (2018). Retrieved June 25, 2018, from https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=CN

Brown, L. R. (1995). *Who will feed China? : Wake-up call for a small planet*. New York: W.W. Norton.

Despommier, D. D. (2011). *The vertical farm: Feeding the world in the 21st century*. New York: Picador.

Fukoto, R. (1990). Mechanism of Action of Organophosphorus and Carbmate Insecticides. *Environmental Health Perspective, 87*, 245-254. Retrieved July 9, 2018.

Gale, F., Lohmar, B., & Tuan, F. (n.d.). *Chain's New Farm Subsidies* (Rep. No. WRS-05-01). Unitied States Department of Agriculture.

Gaodi, X., Shuyan, C., Qisen, Y., Lin, X., Zhiyong, F., Ying, G., . . . Humphery, S. (n.d.). *China 2015*(Living Planet Report, Rep.). WWF.

Glaser, B. S., Funaiole, M. P., & Du, Z. (2017, October 27). How is China feeding its population of 1.4 billion? Retrieved March 23, 2018, from https://chinapower.csis.org/china-food-security/

He, C., Liu, Z., Tian, J., & Ma, Q. (2014). Urban Expansion Dynamics and Natural Habitat Loss in China: A Multiscale Landscape Perspective. *Global Change Biology*. Doi: 10.1111

Hou, B., & Wu, L. (2010, January 24). Safety impact and farmer awareness of pesticide residues. Retrieved July 29, 2018, from https://www.tandfonline.com/doi/full/10.1080/09540105.2010.484858

Howden, D., & Zhou, Y. (2014). China's One-Child Policy: Some Unintended Consequences. *Economic Affairs, 34*(3), 353-369. Retrieved July 9, 2018.

Hvistendahl, M. (2008, March 25). China's Three Gorges Dam: An Environmental Catastrophe? Retrieved March 24, 2018, from https://www.scientificamerican.com/article/chinas-three-gorges-dam-disaster/

Li, H., Zeng, E. Y., & You, J. (2014). Mitigating Pesticide Pollution in China Requires Law Enforcement, Farmer Training, and Technological Innovation. Retrieved June 29, 2018.

Li, W., & Yang, D. T. (2005). The Great Leap Forward: Anatomy of a Central Planning Disaster.

Journal of Political Economy, 113(4). Retrieved June 26, 2018, from https://www3.nd.edu/~nmark/ChinaCourse/Li_Yang_GLF_JPE.pdf.

National Bureau of Statistics of China. (2016). China Statistical Yearbook. Retrieved from http://www.stats.gov.cn/tjsj/ndsj/2016/indexeh.htm

Chapman, P., & Leith, B. (Producers). (2008, May 11). *Wild China* [Video file]. Retrieved March/April, 2018.

Zhang, M., Fang, X., Zhou, L., Su, L., Zheng, J., Jin, M., . . . Chen, G. (2013). *Pesticide Poisoning in Zhejiang, China: A retrospective analysis of adult cases registration by occupational disease surveillance and reporting systems from 2006 to 2010*[Scholarly project]. Retrieved June 29, 2018, from https://bmjopen.bmj.com/content/bmjopen/3/11/e003510.full.pdf

Zhang, Z., Dai, M., Hong, H., Zhou, J. L., & Yu, G. (2002). Dissolved insecticides and polychlorinated biphenyls in the Pearl River Estuary and South China Sea. *The Royal Society of Chemistry, 4*, 922-928. Doi:10.1039/b206891p

Zheng, L. (2018, January 09). Reality Check: Is Beijing's air quality better this winter? Retrieved March 25, 2018, from http://www.bbc.com/news/world-asia-china-42513531

Zhou, J. (2016, October 16). China and (world) food security. Retrieved March 23, 2018, from https://www.sipri.org/commentary/blog/2016/china-and-world-food-security