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China, Climate Volatility

**Adapting China's Aquaculture in Response to Climate Change**

China's history of aquaculture—the process of cultivating fish and other aquatic species for food—began in 1000 BC and has since developed into a booming industry that makes a major contribution to feeding the world. Now, at the turn of the 21st century, aquaculture is facing a problem unlike anything seen before. Climate change, once a hypothetical issue that was easily ignored by the masses, is now at the forefront of the world's environmental concerns. Rising temperatures are causing a slew of issues within the aquaculture industry, and it's putting the global food supply at risk. It's critical that these issues be addressed soon in order to ensure the longevity and continued success of China's aquatic farms. Like all foreign issues, in order to make a lasting impact, it's important to have a deep understanding of the country itself, the challenge at hand, and the possible solutions.

China continues to be the most populous country in the world, with the most recent census totaling 1.41 billion people. 64.82% of the population lives in an urban area, while the remaining 35.18% resides in a rural setting (Textor). The People's Republic of China (PRC), as it's officially named, has a one-party system with President Xi Jinping at the head of the Chinese Communist Party (CCP) (Albert, 2021).

Similar to the United States, the climate and geography of China is incredibly diverse. In the east and southeast, plains dominate the geographical landscape, while the west mainly consists of mountains and plateaus. Most of the country falls into a temperate climate zone. However, the north and west regions are characterized by dry, desert conditions, and the south and southeast experience hot and humid weather with tropical monsoons (Ebrey).

The average family in China consists of two to three people, a trend commonly seen in larger cities and urban areas (Textor). Families typically live in apartment complexes, with each apartment having a balcony, medium to large bedrooms, and a small living room. Meanwhile, family sizes in rural areas still remain relatively high. Here, it's common to see families living in multi-room houses made out of mud and straw with dirt floors (Hays).

Wages vary widely depending on the sector and location in which the people work. The agriculture sector is by far the least paid profession with an average annual wage of $5,508, while the information and IT sector has the highest paid employees with average wages of $22,590. According to location, Beijing, a province-level municipality, has the highest wages at $23,352, while Henan province has the lowest at just $9,420 (Canada). Interestingly, about 34% of people's wages go toward the cost of food, making up the single largest segment of the average person's disposable income (Hays).

The two biggest staple foods in China are rice and wheat noodles with rice being the most popular in Southern China and noodles in the north. Generally speaking, a large portion of dishes

use white meats such as chicken and pork, with fish such as carp, bass, and catfish also being extremely popular. Other options include duck, shrimp, crabs, lobster, and clams. In terms of fruits and vegetables, people in China have similar options that are available within the United States, in addition to fruits and vegetables such as guavas, starfruit, and durians, bamboo shoots, water chestnuts, and bean sprouts. All of this foodstuff can typically be purchased in wet markets where Chinese citizens have access to the freshest meats, seafood, fruits, and vegetables (Hays). In comparison to western culture, China is unique in the fact that people consume very little dairy products and sweets. Deep-fried food is also very uncommon as the Chinese put a heavy emphasis on the freshness and healthfulness of their cuisine (Lin).

Without a doubt, food is a central part of Chinese culture, and seafood is especially interwoven within it. In 2020, the average amount of seafood consumed per person was a whopping 35 kg, and it's estimated that by 2030, China will be an over-consumer of seafood. This is due to two things: the changing preferences of the Chinese people as they seek out other protein sources, and the instability of the pork industry following the recent swine flu outbreak. Today, the country accounts for just over 60% of global seafood production as well as 45% of global seafood consumption (Kurzydlowski). Last year, despite the country's high levels of consumption, China also managed to export $20.8 billion worth of seafood, second only to the European Union (Shahbandeh). As of 2018, China had 7.18 million hectares of land area dedicated to aquaculture. For size comparison, this area is larger than the country of Puerto Rico, but smaller than the Dominican Republic. Inland production is mostly found along the Yangtze and Pearl Rivers, and when organized by province, Shandong and Guangdong lead the country in aquatic production (Kurzydlowski).

Today, China's prosperous aquatic farms are facing new challenges as global climate change issues begin to unfold. As a matter of fact, fisheries in the East China Sea have already seen an 8.3% drop in their number of sustainable catches from 1930 to 2010. Compare this to the global average of 4.1% and it's apparent that China is at the forefront of this issue. If nothing is done to improve current aquaculture systems and lower greenhouse gas emissions, scientists estimate China's aquatic production to drop 16% by the year 2090 (Neslen).

Rising temperatures are the most direct consequence of global warming, and it has especially detrimental effects on fish populations. Within the next century, scientists are predicting an average 1.5°C increase in global temperatures. Although it seems small at first, it's a large change for aquatic species because they are especially adapted to detect even the slightest change in temperature. Higher water temperatures are linked to altered physiology and metabolism, which affect feeding behavior and growth patterns in both finfish and shellfish species. Cold-blooded fish are particularly vulnerable to these temperature increases as they reach their maximum thermal tolerance levels and begin suffering from thermal stress. Prolonged stress will, without a doubt, lead to increased mortality rates in all fish populations (Maulu).

Another effect of climate change on aquaculture is the increase in harmful diseases and algal blooms. It's predicted that bacterial, fungal, viral, and parasitic diseases are all likely to increase as the temperature rises. Species which have already been exposed to thermal stress are at the highest risk of developing these diseases and, because of the warmer environment, they are also more likely to transmit the disease as the replication rate of the pathogen increases. In addition to

the greater occurrence of disease, algal blooms are expected to increase as well. Depending on the species of algae, this could negatively impact aquaculture systems in China as some algae release harmful toxins that could further stress or even kill fish that live within the same environment. In recent years, Chilean aquaculture has suffered from this exact issue with harmful algae. The issue was directly linked to temperature increases due to climate change, and today, it's regarded as the world's largest unprecedented loss of fish ever recorded in history (Maulu).

One major indirect effect of climate change can be observed within the aquaculture supply chain. Capture fisheries, which differ from aquaculture farms in that people harvest fish from the wild, are currently the main source of both protein and wild broodfish for aquatic farms. However, these capture fisheries are already seeing a decline in their wild catches, leaving man-made aquaculture farms at a loss for supplies that are essential to their production. Inputs like fish meal and fish oil, which make up the greater portion of fish feed, are already becoming increasingly scarce. This is leading to higher prices and making it much more difficult for small-scale fisheries to continue operating profitable aquaculture farms (Maulu).

With such a large issue at hand, it's important for China to be adaptable and implement both short-term and long-term solutions. In the long-term, China needs to seriously consider reducing its carbon dioxide output (Maulu). One promising method to achieve this goal is to utilize carbon capture and storage (CCS) technology, which allows large, industrial factories and power plants to capture over 90% of their carbon dioxide emissions. There are currently 26 commercial-scale facilities around the world that have already implemented this technology, and 34 others are in the process of implementation (Carbon). One such facility, Petra Nova, was successfully constructed in Houston, Texas in December 2016. The project was originally funded with a $195 million grant from the U.S. Department of Energy, and it later gained funding through joint partnerships with JX Nippon and Hilcorp Energy (NRG). Petra Nova was just one facility that allowed the United States to make huge strides in achieving the climate goals stated in the Paris Agreement. Although project costs were quite high, the costs and feasibility of alternative technologies would have been much higher if CCS technology were not used (Irlam). According to the Center for Climate Change and Energy Solutions, CCS technology can effectively reduce global warming by 14% by the year 2050. On an industrial scale, this is by far the most efficient way to make large strides in our battle with climate change within the next century (Carbon). China would especially benefit from this technology, seeing as the country houses many industrial factories and power plants, and they should be able to implement CCS at a lower price than the United States due to the lower costs of labor and equipment (Irlam).

In addition to carbon capture and storage, one step that will be particularly important for China to implement is to reduce overall dependency on coal-based power plants. The country is currently the world's largest coal producer and consumes about half of the world's coal. Despite signing the Paris Agreement in 2015 and pledging carbon neutrality by 2060, China has proceeded with construction of new coal-based power plants in order to continue the process of urbanization and growing the country's economy. The few environmental pledges that the country has created will not be enough to fulfill the Paris Agreement by the target deadline. However, if coal-based power plants were halted completely, it's estimated that the loss in revenue after just one year would be ¥4.5 trillion ($655 billion) (Lelyveld). A much more feasible solution, and one that would better align with goals stated in the Paris Agreement, would

be to implement CCS technology on current coal power plants while slowly integrating more renewable energy sources throughout the country. While initial costs would be high, the cost of pollution itself is valued to be approximately ¥1.5 trillion ($227 billion), and there is currently no other method to dramatically reduce carbon emissions in the short term. Utilization of NGOs has been ineffective in the past, so the majority of the funding for this project must be through the Chinese government. In order to gain funding and support, it's critical that officials and policy makers are aware of the long term benefits of reducing emissions, as well as the fact that this solution will *not* halt China's economic growth (Maizland).

In the meantime, China must implement its own set of solutions specifically geared towards their aquaculture industry. One way that could help mitigate the effects of climate change is through the use of integrated multi-trophic aquaculture (IMTA). Developed by the Yellow Sea Fisheries Research Institute (YSFRI) in China, this approach is designed to increase the sustainability of intensive aquaculture farming. Here, multiple different species are raised within the same environment in a way that is specifically designed to enhance the system's nutrient cycles and waste processing systems. If this process is combined with the selection of the most climate-adaptable species, aquaculture in China can continue to prosper (Kritzer). Not only does this method increase overall efficiency and offset the effects of climate change, but it has also been found to reduce public opposition to intensive aquaculture farming practices (Correia). The Environmental Defense Fund and the China Academy of Fisheries Sciences have partnered together to formulate a plan to implement the IMTA approach to China's aquaculture systems. By working together with the CCP, which has already shown its support for improving fisheries, this would be a viable option to keep China's aquaculture sector running strong (Kritzer).

IMTA would directly solve China's environmental issues related to aquaculture, but there still remains a supply and economic issue with the sector. Traditional fish meal and fish oil will soon no longer be a feasible option for most aquatic farms due to rising costs and the instability of capture fisheries. Luckily, there have already been large strides in scientific research and development, and soy-based feed substitutions have already been formulated and implemented in some of China's aquatic farms (Maulu). Currently, the price of traditional fish meal is $1,429/ton while the price of soy-based feed costs half of that value (China's). Not only is soy a much cheaper alternative, but it is also a great source of highly-digestible protein that is available for purchase year-round. Because of this, it should be relatively easy for both small and large aquatic operations to implement the new feeding plan (Knupp). Researchers have also designed a projected model that predicts a 25% increase in production by 2050 if greenhouse gas emissions are reduced and 25% of current fishmeal products are replaced by soy-based feeds. Under this same scenario, researchers also estimate that aquatic production will increase by 31% by the year 2090 (Holmyard). The US Soybean Export Council has recently been working with Chinese farmers to meet their fish feed needs and help improve the sustainability of their operations. The council is continuing to build relations with China and create a higher demand for US soy products in hopes of one day becoming China's leading supplier of soy-based fish feed (Knupp).

There's no shortage of new technologies that can help mitigate or solve the issues brought on by climate change. However, additional actions must be taken in order to implement these technologies into the greatest number of China's aquatic farms. The CCP has already stated in their 5-Year Plan their wish to improve the country's fisheries, and they are willing to stand

behind that through government funding (Kritzer). In order to accomplish their goal, they should consider establishing government incentive programs which would encourage aquaculture enterprises to become more “green” and sustainable. These incentives may include things such as tax breaks, grants, and zero-interest financing opportunities. In addition to these efforts, the government or another recognized organization should set specific standards for what’s actually considered “sustainable” in an effort to create a sustainability certification program (Metian). This will provide another layer of incentives for producers, as well as encourage the consumers to purchase the certified products.

Another possible solution that could be further capitalized is aquaculture insurance. This type of insurance scheme already exists, however it does not currently cover losses due to climate change. Surveys have also found that only 5% of all aquaculture enterprises in China were covered as of 2018. Small, rural farms were least likely to purchase coverage due to the fact that the insurance premium was too expensive for the scale of their operation. In addition, mid-sized operations were skeptical of purchasing insurance because of dissatisfaction related to slow claims processing. Improving customer satisfaction and creating more affordable premiums would increase the number of insured farms, thus allowing small-scale aquaculture enterprises to stay afloat during these changing and uncertain times. By expanding insurance coverage, China would provide smaller farms with the necessary economic support to continue production while simultaneously allowing them more time to implement sustainable practices (Stabilizing).

Fortunately, aquaculture is an incredibly resilient branch of agricultural production. While the issues brought on by climate change undoubtedly pose a serious threat to China’s fisheries and the global food supply, there’s still hope for the future. By understanding the situation and using that knowledge to implement a plan of action which attacks the issue on multiple fronts, China will be able to continue being a global leader in aquaculture production. Reducing emissions in addition to making changes to the aquatic environment and food sources will be a crucial step in the right direction. Only in this way can aquaculture continue to be used as a viable method to feed the world.

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