國立臺灣大學社會科學院政治學系

碩士論文

Department of Political Science

College of Social Sciences

National Taiwan University

Master's Thesis

東亞糧食安全及其未來發展

Food Security in East Asia in the Present and Near-Future

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中華民國113年10月

October, 2024

doi:10.6342/NTU202403546

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Declaration

1. I hereby declare that I have compiled this thesis using the listed literature and resources only.
2. I hereby declare that my thesis has not been used to gain any other academic title.
3. I fully agree to my work being used for study and scientific purposes.

In Prague on 30 July, 2024 Eric Shahin Scholz

doi:10.6342/NTU202403546

References

SCHOLZ, Eric. *Food Security in East Asia in the Present and Near-Future*. Praha, 2024. Master's thesis (Mgr.). Charles University, Faculty of Social Sciences, Institute of Political Studies. Department of Political Science. Supervisor PhDr.Bohumil Dobos, Ph.D.

Length of the thesis: x characters including spaces, without abstract or appendices

doi:10.6342/NTU202403546

Abstract

This thesis contains an analysis of the current reality, challenges, and possible future outcomes of food security in East Asia, specifically analyzing the four country case studies of the Republic of China (Taiwan), People's Republic of China (China), Japan, and South Korea. Its goal is to get a full analysis of these countries' abilities to sustain themselves, and if they are prepared for current and future challenges. These countries have emerged in one of the most dynamic regions of the world, having grown rapidly in wealth while also existing in a region of a multitude of geopolitical flashpoints, and an analysis of their ability to sustain themselves going into the future or to act resiliently in the face of crisis is important to understand their fragility or robustness in the face of a destabilized, globalize world. Specific emphasis has been put on ability to feed themselves with domestic production, analysis of their food supplies internationally, and how their systems will fare in the case of environmental degradation, regional conflict, and international disruption.

Keywords English

Geopolitics, Food Security, Taiwan ROC, South Korea, China PRC, Japan,
Supply Chains, Agriculture, Globalization

Keywords Chinese

地緣政治、糧食安全、台灣、中華民國、中華民國台灣、南韓、中華人民共和國、中國、日本、供應鏈、農業、全球化

doi:10.6342/NTU202403546

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1. Introduction

Food security remains a critical and multifaceted issue within the realm of geopolitics and its role as a strategic resource, particularly in the dynamic and economically influential region of East Asia. This thesis delves into the intricate interplay of geopolitical and geographic factors influencing food security in Taiwan, South Korea, Japan, and China, examining the ways in which these nations navigate challenges such as resource scarcity, economic conditions, climate change, and geopolitical tensions, with specific emphasis put on environmental decay, potential regional conflict, and future international disruptions. The convergence of these factors poses significant implications for regional stability and development, making a comprehensive analysis not only relevant but essential for understanding the region in terms of self-sufficiency and reliance on globalization.

Taiwan, South Korea, Japan, and China each present unique yet similar case studies within the context of East Asian food security. These nations, despite their economic prowess, face distinctive challenges in ensuring a stable food supply. Issues as limited arable land, aging workforces, environmental erosion, and globalized economic and ideological factors affect each country. By examining these factors, this thesis aims to provide a nuanced understanding of how each country stands to secure their food systems against both internal and external pressures.

Furthermore, the geopolitical dynamics in East Asia, characterized by historical conflicts, territorial disputes, and shifting alliances, play a pivotal role in shaping food security strategies.

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The interdependence of these nations on global trade networks and their varying degrees of vulnerability to international market fluctuations underscore the geopolitical dimension of food security. Through a thorough analysis of policy frameworks, international relations, physical geographic considerations, and economic priorities, this thesis seeks to elucidate how food production and self-sufficiency (or a lack thereof) are interwoven with the efforts to achieve sustainable food security in Taiwan, South Korea, Japan, and China. This exploration not only contributes to academic discourse but also offers practical insights for policymakers navigating the complexities of food security in an interconnected world.

2. Methodology

In this research paper I explore the issue of food security in East Asia. I analyze the data of food production and imports in each of the countries and hypothesize possible future trends and outcomes in the possible situations of global disruption, regional conflict, and environmental destabilization brought on by both climate change and local pollution and erosion. Data used includes government documents and reports, analyses from think tanks specializing in strategic studies, economic data on local production and imports, estimates on potential output, and what challenges each country might face in this regard. Additionally, this analysis is done through a geopolitical lens, acknowledging food as an essential resource important for social stability and a state's survival that is influenced by and influences geopolitical factors, and that without food security any given state is at significant potential risk. This will be done as case studies of four

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countries using a quantitative approach to answer the questions of: How food secure are these countries? What are they doing to maintain food supplies for their population? And how might their food-supply strategies perform in the near-future?

The benefit of this methodology is to be able to understand what each country is and isn't able to produce, and what they are reliant on, and why they are reliant on these things. It makes certain trends clear to allow for predictions in the future, as well as gives the opportunity to analyze what is and isn't feasible in terms of improving food security or mitigating challenges, for example using smart technology, improving production efficiency, reducing food waste, combating environmental pollution, and so on.

2.1 What is "Food Security"?

The concept of food security is a relatively straightforward one. In short, a state of food security is one where the supply of food and nutrition is secured, meaning there is little or no threat that the subject immediately or in the near future will have difficulty procuring food. A state of food insecurity is a state in which the subject has difficulty or inability to easily procure the minimum amount of food required to support itself. A more technical definition that was coined at the World Food Summit in 1996 is that food security is "a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and preference for an active and healthy life." Furthermore, they went on to add for major aspects to its definition:

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- "*Physical availability of food: Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.*
- *Economic and physical access to food: An adequate supply of food at the national or international level does not in itself guarantee household level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives.*
- *Food utilization: Utilization is commonly understood as the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals are the result of good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.*
- *Stability of the other three dimensions over time: Even if your food intake is adequate today, you are still considered to be food insecure if you have inadequate access to food on a periodic basis, risking a deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.*"

A definition of food insecurity from the United States Department of Agriculture is "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" (Bickel et al., 2000; Jardine, 2021).

There are several ways to analyze food security. Frequently food security is discussed based on individual households (Food and Agriculture Organization of the United Nations, 2006), but for this study we shall take it at a national level for the purpose of viewing it through a

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wider political-economic lens. Analyses of food security have also often analyzed the issue purely on caloric data, i.e. simply determining if the subject is food secure or insecure based on gross caloric intake. In more recent times this has expanded to also include the nutritional content of the food instead of raw calories.

In recent eras food security has also been closely tied to geopolitical stability. As countries industrialize and specialize and trade systems become more complex some countries rely on imports from foreign partners, and others base entire economies on selling excess food. To better understand the food security of this region geopolitical factors like who their trade partners are and where they are, what potential conflict and confrontations mean for food security in the region, and how global systems and catastrophes can affect them. Being such an important resource, the continued supply of food is essential for these countries, and this continued supply in East Asia in particular goes through a labyrinth of economic and political partners to supply the food, and then navigation of local geopolitical flashpoints to make sure it can even arrive. Therefor an analysis is considered for how reliant these countries are on food imports, from which countries, and how they may fare in the case that they must stand alone.

2.2 Sampled Countries

Four countries have been sampled for this analysis. They are Japan, the Republic of Korea (South Korea), the People's Republic of China, and the Republic of China (Taiwan). These countries were chosen because of both the large amounts of available data about them, as opposed to some other countries in the region such as the D.P.R.K. (North Korea), as well as their significance to the greater international system and economy (unlike Mongolia).

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Additionally, these countries are some of the few that fit a stricter definition of "East Asia," with other nearby countries such as Vietnam and the Philippines often being categorized as "Southeast Asia" in most regional analyses.

These countries are also worth studying because of the myriad of challenges they face, such as aging population, reliance on imports, lack of arable land, and potential for involvement in regional conflict.

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3. Taiwan

3.1 History, Geography, and Demographics

The Republic of China, or Taiwan going forward, rests on the island of Formosa along with some surrounding islands and island chains, such as Penghu, Kinmen, and Mazu, totalling about 32,260km^2. The indigenous peoples of Taiwan are of Austronesian origin, being more culturally similar to the Philippines or even Polynesians than Chinese, and for most of their history were able to primarily live off the land and sea, relying more on hunting and fishing than widespread agriculture, although some did live sedentary lives as rice and millet farmers. These natives tended to live less sophisticated lives than the Chinese, often living in relatively small villages and tribes (Andrade, 2008).

At some point between the 12th and 14th century mainland Chinese had increasing levels of contact with the island, often primarily just for trade, fishing, hunting, or piracy. There was not widespread agriculture on the island until the 1630s, when the Dutch East India Company decided to try to colonize the island. In its method of doing so, the Dutch brought in vast quantities of Chinese people from the mainland to act as their workforce and yeomen (Andrade, 2008).

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The island that these firsts colonists would arrive on would evidently be one of two extremes. In the western portions of the country, Taiwan is very flat and dominated by a large coastal plain. While in the east it is dominated by dense and tall mountain ranges unsuitable for agriculture, aside from the Huadong Valley, a rift valley between the central and coastal mountains stretching from modern-day Hualien and Taitung. As a rather obvious result of this physical geography, almost all of the arable land suitable for farming and ranching is on the western half of the island, as well as the vast majority of its population. In total, about 60% of the island is dominated by mountains. In terms of climate, the island is also quite warm, ranging from temperate to tropical, and being very wet, especially because of the lengthy typhoon season the island experiences from July to September, with most occurring in August. Because of its climate and the nature of rice farming, Taiwan is able to produce two harvests a year (Andoko, 2021; Chang, 1952; Shan, 2022).

The Dutch-controlled colonization effort very explicitly pushed for the growing of cash-crops on large-scale plantations manned by Chinese laborers. Of these crops the primary one was sugar cane, followed by rice, wheat, ginger, tobacco, indigo, hemp, cotton, and whatever other valuable produce fitting tropical and subtropical climates of the island. The plantation-colony was very lucrative, and to encourage more Chinese laborers to come over the Dutch authorities began establishing hospitals and granting them property rights, which also resulted in continuous habitation and long-term settlement (Andrade, 2008; Lee, Yang, 2015).

But even in these early days, with few inhabitants and many open fields to work in, there were issues procuring enough food. Early Taiwan was reliant on rice imports from China, not

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just because early efforts were on crops for export, but because a drought struck Taiwan and the typhoon season ended early in 1638, and the taller mountains made traditional Chinese methods of irrigation from higher water sources into the valleys very difficult. The result was a massive failure in that year's rice harvest, forcing many workers to rely on eating sugarcane (Andrade, 2008).

From that point on until the current day Taiwan was continuously inhabited by Chinese, and later Japanese, colonists for the purpose of agricultural production, meanwhile rice and sweet potatoes developed as the island's traditional staple foods, while valuable crops were sent for export. The history of this is long and complicated, but not suitable for this paper, but what is notable is its history with food.

Between 1895-1945 Taiwan was a Japanese colony, and like its time under the Dutch its primary exports were agricultural. In 1939 Taiwan was the world's third largest supplier of bananas and canned pineapples, fourth largest producer of sugar and sweet potatoes, and after its *de facto* independence since 1949, in the 1960s it supplied 1/3rd of all of the world's mushrooms (Crook, 2023; Lee, Yang, 2015).

In 1905 the island of Formosa had a population of slightly over 3,000,000 people and had over 3,125,000 acres (12,650km^2) of arable land, with only 1,336,000 (42%) of those acres (5,400km^2) in use (Yosaburō, 1907). By 1950 that population had increased to over 7.6 million people, by 1986 over 19 million, to almost 24 million as of 2024 (Chang, 1952). Meanwhile its amount of arable land has decreased to 7,870km^2 , or about to about 62% of what it was in 1905,

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largely because of arable land falling victim to urban development, as can be seen in Figure 1. ("*Taiwan land use: Land area: arable land and permanent crops*," 2023).

Taiwan's food self-sufficiency has declined over the years. In 1986 Taiwan's food caloric self-sufficiency rate was at 56%, meaning of course that Taiwan was able to provide more than half of the calories it required ("*Taiwan's food security and the Food Loss Paradox*," 2023). By 2009 that number had dropped to 32% (Andoko, 2021). This is not purely because of population rise and loss of arable land however, it is also in-part due to consumer preferences. The Taiwanese palate has changed over the years and with its growing affluence and interactions with the West. Subsequently, demand for things such as potatoes and wheat, which struggle to grow on the jungle island, have increased massively over Taiwan's history, while consumption of rice has declined. Additionally, the consumption of meat has increased. In 1961 plant-based protein accounted for 74% of Taiwan's protein intake, and that number has plummeted to only slightly above 50% in 2017, and Taiwanese households now spend more money on purchasing meat than any other food product (Ferreira, Critelli, 2023).

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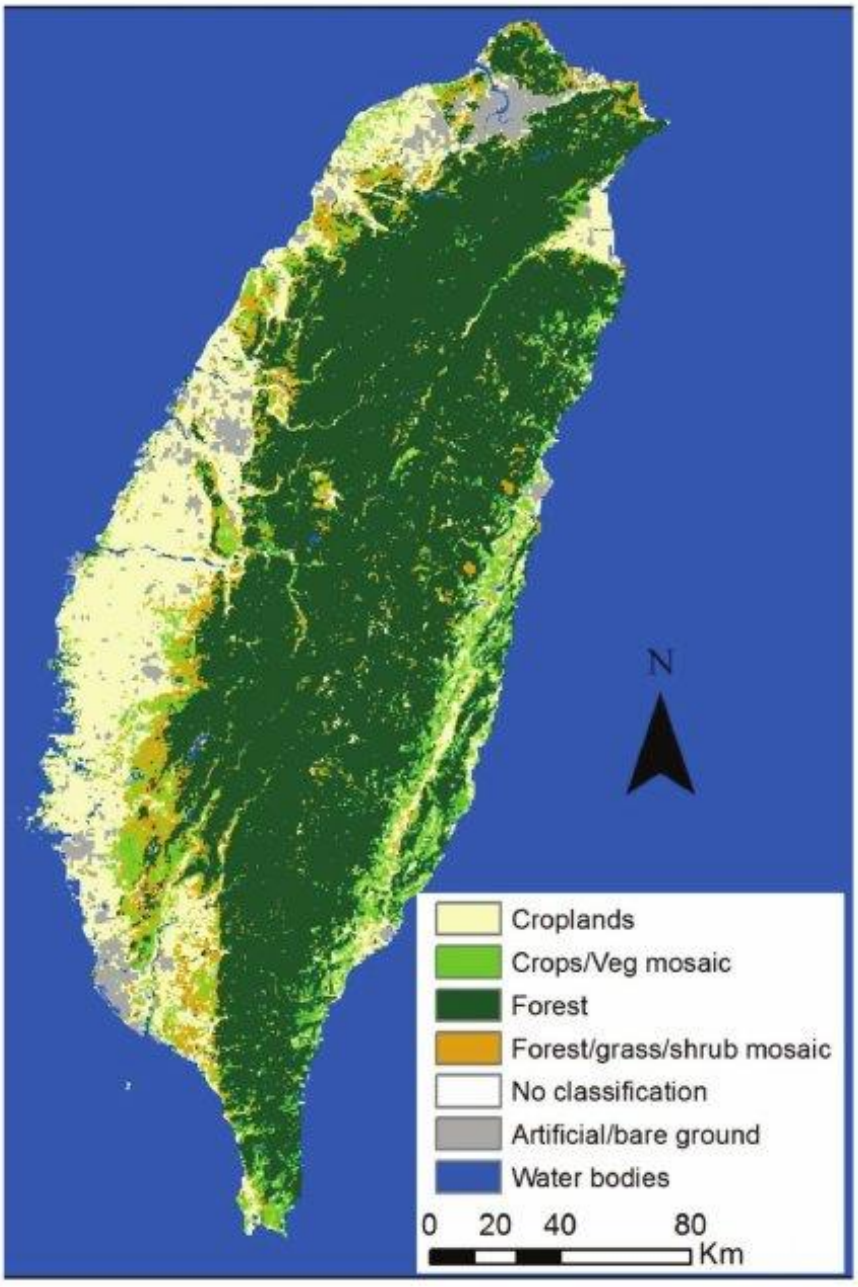

Figure 1: Map of Formosa island by land use. "Artificial/bare ground" refers to built-up urban areas.

Source: Wardrop et al., 2013

The prime contributor to these rapid population growth, urbanization, and growing ability to afford imports was of course economic growth. Taiwan developed its economy very rapidly over the course of the 20th century, going from a relatively backwater plantation-colony, to a

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high-tech, wealthy, developed nation. This also had the effect of Taiwan and Taiwanese people prioritizing more economical sectors over agriculture, resulting in a massive shift as the population moved from farms in the countryside to factories in the city, thereby reducing the amount of people wanting to do the actual work of farming. In 2019 agriculture accounted for less than 2% of Taiwan's GDP and employed 4% of the Taiwanese workforce, a massive decline from the 1960s when agriculture accounted for 30% of the economy (Ferreira, Critelli, 2023). Even in more recent decades after the industrialization had taken hold there were large shifts; in 1992 agriculture made up over 5% of exports by value, which was more than halved in a decade by 2003, and halved again down to less than 1.4% in 2021 (Crook, 2004).

Needless to say, with all of these dramatic changes food security is more of a challenge now than it was decades ago.

3.2 Current Status

Taiwan in the year 2024 currently stands at a point of having low self-sufficiency. With 22.1% of its total area being used for agriculture, in terms of calories Taiwan is only able to supply for itself about 40% of what it needs (Ferriera, Critelli, 2023; "About Ministry of Agriculture: Overview"). However, there are certain agricultural and food sectors where Taiwan is almost self-sufficient, or even produces more than it consumes and can safely export. Between 2009-2018 Taiwan produced almost 170% of the seafood it consumed, and 100% of its eggs, giving it two fronts for supplying high-protein foods, as well as 97% of its rice (Wu-Chung, 2020). Unfortunately, these are the only sectors where Taiwan has proven to be fully self-

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sufficient. In terms of fruit, vegetables, and meat Taiwan produces 85%, 89%, and 80% of its needs respectively. After these categories, which are admittedly some of the most important, the situation becomes much more dire. Taiwan produces only 31% of its dairy, 27% of its overall crops (such as wheat and soybeans), and less than 4% of its cooking oil. While having a surplus of seafood and being able to supply the majority of its fruits and vegetables may seem reassuring, the most consumed goods in Taiwan tend to fall into the category of "crops:" wheat, rice, soybeans, sesame, and sorghum (Andoko, 2021).

Naturally, Taiwan must import what food categories it can not produce enough of on its own. Taiwan's largest source of food imports is the United States, followed by the P.R.C. (China), Brazil, New Zealand, Japan, Thailand, Australia, U.K., France, and Malaysia. By far, the United States is its largest supplier, selling more food to Taiwan than China, Brazil, New Zealand, and Japan combined. As of 2021, the amount of food imported from these top-ten countries is over $10.6 billion, with almost $4 billion coming from the United States (Andoko, 2021).

The cause of Taiwan's food insecurity and dependence on imports is not merely the aforementioned decline in arable land over the 20th century, the rapid increase in population, and economic incentives for workers to pursue industrialized labor. The Taiwanese agricultural market also includes particular structural issues hampering its efficiency. The vast majority of Taiwanese farms are small, family-owned plots of land with an average size of only a measly 1.1 hectares with very few large-scale farming operations or agricultural corporations ("About Ministry of Agriculture: Overview").

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Figure 2: An example of an extremely small Taiwanese farm in Hualien, Taiwan. Source: Eric Scholz, 2024.

Figure 3: An example of a small Taiwanese farm in Puli, Taiwan. Source: Eric Scholz, 2024.

A result of Taiwan having many small-scale farms is the diseconomies of scale, that being that many small operations are less efficient than fewer large operations. A result is not only less food production, but also higher costs of domestic production, making local produce less competitive with international prices and imports, further disincentivizing Taiwanese people to either work in agriculture or support local producers via consumption. This means that Taiwan

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could feasibly have higher levels of food output for cheaper prices while utilizing the same amount of agricultural land it does today, and probably with fewer workers, if it were to consolidate its food production to be less decentralized (Andoko, 2021; Ferriera, Critelli, 2023; "*Taiwan land use: Land area: arable land and permanent crops*," 2023).

The demographics of Taiwanese agriculture also further complicate measures. While over 22% of Taiwan's surface area is used for agriculture, 79% of the population lives in urban areas and cities. While Taiwan is not very large, this creates the additional logistics of having to transport food farther distances from the farmlands to the center of cities, compared to if the population lived in a more dispersed manner. Additionally, the vast urbanization has led to some decline in small towns, with many young people going to these new man-made habitats for work and education, leaving the rural countryside depopulated and aging. Subsequently, the average age of Taiwanese farmers is 62-years old. Relying on people nearing retirement age (retirement in Taiwan is age 65) for the manual labor of supplying your food, coupled with diseconomies of scale and lack of industrialized equipment no doubt leads to massive inefficiencies in Taiwanese agricultural production ("About Ministry of Agriculture: Overview").

Another difficulty in Taiwan is rampant food waste. In 2018 a whopping 40% of Taiwanese vegetables ended up as waste. In 2023 there was also somewhat of a domestic scandal; an egg-shortage caused by an outbreak of avian flu led the government to launch a program to import 145 million eggs to make up for domestic shortfalls. However, approximately 54 million of these eggs (valued at about 6.5 million USD) were destroyed and disposed of, as they had expired after improper storage and decrease in demand for them as local egg producers

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rebounded (Ferriera, Critelli, 2023; "*Taiwan land use: Land area: arable land and permanent crops*," 2023).

Reasons for this food waste usually begin with lack of proper storage. Taiwan's climate is naturally warm and wet, with the island's average temperature being 23C. Food will spoil faster in warmer, wetter environments compared to colder, dryer environments, and more effort needs to be put into keeping perishable goods, such as by building vast, refrigerated storage facilities. Other forms of food loss can mostly be attributed to mismanagement and poor logistical systems, such as damage to goods at supermarkets, discarding of food with blemishes, slow sales resulting in spoilage of certain goods due to production and import imbalances. All of these issues can be largely mitigated, but as of currently still persist as issues (Andoko, 2021; Ferriera, Critelli, 2023).

On top of chronic issues, Taiwan has been particularly challenged in the last few years to meet self-sufficiency, as the country has been in its worst drought in the last 60-100 years. Taiwan's dry season is usually November to April, with May to October being the wet season. To a visitor of Taiwan it may seem like there is no dry season whatsoever, but many parts of the island rely on the typhoons from May to October for the majority of their rain. In northern Taiwan, where the capital of Taipei is located, about 40% of its rainfall comes during the dry season, and 60% in the wet season. But in the south only a meager 10% comes during the dry season, with the remaining 90% in the wet season. As mentioned, much of this rainfall comes from typhoons, with Taiwan usually being affected by about 12 of them a year, with about 3-5 actually making landfall on the island instead of only affected it along its fringes. However, for a

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period from late 2020 to late 2023 Taiwan not a single typhoon made landfall on Taiwan, seriously dampening overall water supplies (Kai-Yuan, 2022; Lin, 2023).

The effect of this drought on Taiwanese agriculture has been very severe. In previous years during the rainy season the reservoirs would release water manually to prevent flooding caused by heavy rain. For the last several years Taiwan has been so dry that some reservoirs would not schedule a manual release even as the wet season was beginning, which was unheard of previously (Kai-Yuan, 2022). In 2023 there was some rebound, with reservoirs sitting at 87% capacity in aggregate towards the end of the dry season, but sat at around 50% in 2020, and some reservoirs got as low as 10% in 2021. But as previously mentioned the south of the island is more reliant on the wet season and has been more severely affected, so while the aggregate is 87% some southern reservoirs such as Baihe Reservoir near Tainan City is only at 30% (Kao et al., 2023; Narvaez et al., 2022).

What was a gross 70% decrease in rainfall on the whole island had serious negative effects on agriculture. Authorities cut water from the irrigation systems of about 1/5th of the island, affecting a myriad of crops, most notably rice which requires a large amount of water. As a result of the loss of water many rice crops were unable to fully mature and ended up being sold as animal fodder. The water shortage also resulted in economic damages, with the island's tea harvest falling by 50%, water rationing in the island's center, and even a shortage of hydroelectric power that resulted in two major blackouts in May 2021(Narvaez et al., 2022). Near the worst of the drought in 2021 the government was forced to make tough choices about where what water they did have would go. Many businesses such as car washes and hair salons

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were asked to decrease water consumption at the same time water was rerouted from farmers so that it could go to industrial processes, primarily microchip factories. Taiwan Semiconductor Manufacturing Company consumes 7% of all of Kaohsiung's water alone (Kai-Yuan, 2022; Sui, 2021).

Taiwan had not prepared itself adequately for this drought. The actual price of water being too cheap on the island; Taiwan had some of the lowest set water prices in Asia at $0.37 per ton of water, which is about one-quarter of American water prices and less than one-tenth of Europe's, and Taiwanese people spent 0.6% of their income on water, compared to almost 3% in Japan. Results of these very cheap water supplies include giving consumers little incentive to try to conserve water, as wasted water was essentially paid for by taxes, or disincentivizing investments in water preservation infrastructure, as recycled water is more expensive than unrecycled. Despite this very cheap water and Taiwan being one of the wettest developed economies of the planet, it's can be considered a water-scarce place, with amount of water available per capita being 1/6th of the world average as of 2015, years before the drought even started (Kai-Yuan, 2022; Narvaez et al., 2022).

Another issue contributing to Taiwan's water issues is simple, physical infrastructure. For example, in 2015 almost 17% of water was lost to leaky pipes.

3.3 Potential Future Challenges

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Taiwan's food security is far from certain. In fact, it is very unlikely to develop food security without drastic overhauls of their agricultural systems. Such an overhaul would have to include things such as highly-efficient use of the limited land, through means such as mechanization or extensive use of greenhouses. Even then, Taiwan would be unable to meet self-sufficiency of certain food-types, such as beef. But here we shall see how Taiwan might be able to at least maintain the *status quo* in case of a crisis.

3.3.1 Environmental Degradation

Like all countries of the globe, Taiwan is subject to global climate change. One of the dangers of climate change is that the specific changes to the climate are unpredictable, and therefore are impossible to completely prepare for. However, there are some specifics that we may be able to predict.

For example, the sea levels around Taiwan are already rising at twice the global average as a result of melting of polar ice caps because of temperature increases. Taiwan, being an island where flat land is an important resource, is of course particularly vulnerable to such things. Taiwan could lose significant portions of its coastal plains where most farms are based, which would of course mean fewer farms and less food production, as well as displacing people from urban areas that would then need to expand or build new urban areas in other parts of the country (Mien-Chieh, 2020).

Another issue that is already affecting Taiwan is drought. As previously mentioned, Taiwan relies on typhoons for a large portion of its freshwater supply, and over the last five years the number of typhoons have been very few, even down to 0 in some years. Even before then,

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between 2010-2020 the average amount of typhoons to reach Taiwan had decreased to around 2.5 from a usual 3-4 (Jensen, 2020). Some models predict that his decrease in the amount of typhoons would continue, eventually reducing Taiwan's annual rainfall would decrease by 40-60% by the end of the century. This massive drop in rainfall, combined with rising temperatures would make Taiwan hotter and dryer, meaning it would become less and less suitable for farming the staple crop of rice, which would drastically hamper Taiwan's food security (Hui-Ju, Hetherington, 2020).

Another catastrophe that would affect Taiwan is off of its shores. Raising water temperatures results in coral bleaching, which results in the death of coral reefs. Coral reefs are hotspots for sea life, meaning that without coral reefs Taiwan's fishing industry would drastically suffer. Unfortunately, coral reefs around Taiwan are bleaching and dying off. In fact, almost 1/3rd of Taiwan's coral reefs are already in the irreversible process of dying, while 52% are under some degree of heat stress, which will significantly decrease the available fish stocks in local waters. ("Bleaching Killing at Least 31% of Taiwan's Reefs," 2021).

Therefore, without significant environmental mitigation efforts and improvements throughout Taiwan's food production, levels of self-sustainability will almost certainly decline in the near-future.

3.3.2 Regional Conflict

The Taiwan Strait is often considered one of the world's most likely flashpoints for international conflict, due to the dispute over the true legitimacy of the Republic of China (Taiwan) and the Peoples' Republic of China. Additionally, declaration of independence by

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Taiwan, to turn into something such as the Republic of Taiwan and to claim definite separation from the mainland is considered a redline by the powers in Beijing that would spark a conflict.

In the case of potential conflict with Beijing, or some other possible regional conflict that either Taiwan would be dragged into, or would disrupt internationally in the area, Taiwan would be in a poor position. As previously mentioned, Taiwan is currently heavily reliant on food imports. If Taiwan would be unable to import because of something like infrastructural damage or a blockade, it would suffer greatly.

All of Taiwan's agricultural imports arrive via one of four ports: Keelung, Taipei, Taichung, and Kaohsiung. A serious issue of this is that all four of these ports face either westward, or in the case of Keelung, northwest, towards the Taiwan Strait. This means that even a partial blockade of Taiwan would completely cut off its abilities to import food, with there being not a single large port on Taiwan's eastern, Pacific coastline that faces towards its primary food supplier: the United States (Ferriera, Critelli, 2023).

The United States Army War College outlined three possible scenarios: a full-blockade of Taiwan that prohibits any food imports, a partial blockade or a porous blockade that could allow some food imports, or sufficient predictions of a future blockade to push Taipei and Washington into preparing ahead of time.

The first scenario would be the most devastating for Taiwan, and it would be forced to fend for itself. Taiwan currently has a 6-month strategic supply of rice, and 3-months of other

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foods. Should such a blockade last longer than 3 months, the Taiwanese would be forced to survive from rice, which while having calories lacks many important nutrients such as protein. In the case of a blockade past 6 months, Taiwan would need to come up with other means. Such means could include things like American style “victory gardens” that existed during the Second World War, in which civilians are encouraged to produce as much of their own food as possible and use of everything down to city parks to grow staples such as rice and sweet potatoes, but this would be far from a perfect solution (Ferriera, Critelli, 2023).

In the second scenario Taiwan would not have to wholly rely on reserves and domestic production, but it would still likely not be enough. To match the volume of just soybeans imported by Taiwan in 2021 would require 47 Panamax-size vessels, or about 60 Lockheed C-5 Galaxy aircraft. If the vessels are unable to reach one of Taiwan’s four ports, airlifts would be the only possible reprieve, and even then the logistic requirements would not possibly be met, and would only be able to prolong Taiwan’s untenable situation (Ferriera, Critelli, 2023).

In the third situation where some preparation is possible, the situation would still not be ideal. Even given a 6-month preparatory phase, Taiwan does not currently have the logistical capabilities to store enough food. Vast refrigerated warehouses would have to be built on short-notice, creating a bottleneck for how much food could actually be stored. While bases in the north of the Philippines would act as effective logistics hubs to transport the food to Taiwan’s southern Kaohsiung, the amount of food Taiwan could receive would be limited by its domestic facilities. Thus, even if Taiwan could double, triple, or even quadruple its food storage abilities on short notice, this would still mean a maximum 2-year rice reserve, which could theoretically

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be enough time to sit-out the conflict, but given the length of many modern conflicts this seems unlikely (Ferriera, Critelli, 2023).

3.3.3 International Disruption

As may be obvious for a country so reliant on imports, Taiwan is relatively vulnerable to disruptions in the international system and agricultural market, but not as seriously as it could be. For example, one of the recent effects of the conflict between Russia and Ukraine has been global food instability, as the two nations, both leading world suppliers in wheat, fertilizer, and significant suppliers of other goods, have either had their infrastructure damaged or have been subject to international sanctions. However, Taiwan had escaped from this crisis mostly unscathed, having imported only 0.8% of its wheat from the two countries combined, instead largely depending on the United States and other Asian or Latin American countries (Andoko, 2021; Chen, 2023).

Taiwan was not totally immune to the effects, however. The subsequent global shortages resulted in increased prices globally, making Taiwan's imports more expensive, thus of course meaning that they can import less for the same prices as before. The reliance on the United States for food imports, along with other relatively stable countries like New Zealand, France, Thailand, etc. means that Taiwan is relatively secure. Alongside this system, Taiwan has systems in place to grant emergency subsidies for fertilizer and animal feed in case of a widespread disruption.

Yet Taiwan does have two major vulnerabilities. One is that the overwhelming reliance on imports from America means that if any crisis were to happen in America, such as drought,

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civil unrest, or major economic issues, it would disproportionately affect Taiwan. The second issue is that as many developing countries rise in living standards they are able to buy more and higher-quality food on the international market, which would raise prices and increase competition for Taiwan to be able to import.

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4. China

4.1 History, Geography, and Demographics

The People's Republic of China (PRC), or China going forward, is a huge country of 9.6 million km^2, which makes it the fourth largest country in the world, being slightly smaller than the United States of America but over 1,000,000km^2 larger than Brazil. The country has a variety of diverse ethnic groups, ranging from the Tungusic Manchus in the north to Muslim Turks in the far west to more Inodchinese Tai people in the south. Climates throughout the state also vary drastically; most of the population lives in the temperate and subtropical center-east, while to the north it gets as extreme as the subarctic, and to the far south into tropical monsoon, and in the south west to mountain-tundras, and north west to sand deserts. It is a land of many extremes.

Agriculture in China is believed to go so far back into the past to be beyond recorded history, having started at least over 8,000 years ago, or perhaps as early as 13,500 years ago, along the Yellow River that flows east-west in the northwest of China. Such a long history is hard to summarize, but what is important is that rice developed as a common staple crop, and pigs as the most common source of domesticated animals for food (Long, et al., 2018).

A major benefit of rice as a crop is that it tends to be more calorie-dense per an acre, although also more labor intensive. This is because, depending on climate, it is possible to have up to two rice harvests per a year, called "double-cropping," rather than just one, but it also requires extensive water and irrigation, as well as much tedious manual planting (Ferriera, Critelli, 2023). Somewhat later, but still many thousands of years ago, millet was domesticated in

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China, taking up a niche in Chinese agriculture in the north. Whereas the warmer, wetter south of the country was quite suitable to rice, in the north millet was able to survive in the drier, colder conditions where rice could not (Crawford, 1970).

The dominance of rice lasted for most of Chinese civilization, with supplements in the likes of millet and other vegetables but would undergo a large change with the Columbian Exchange in the 1500s. During this time many New World crops from the Americas spread throughout Eurasia, including corn, which also took root in China. This myriads of effective crops through a range of climates and large river basins is, of course, partially to blame in China having long held the title of the world's most populous country until 2023 when it was surpassed by India, but still with a gargantuan population of 1.42 billion people. Indeed, the 19th and 20th century saw China's population grow 14-fold, with a population of 150 million in 1800, to 300 million in 1900, to almost one-and-a-half billion today (Li, 1982; Najafizada, Pradhan, 2023; Nowakowski, 2015).

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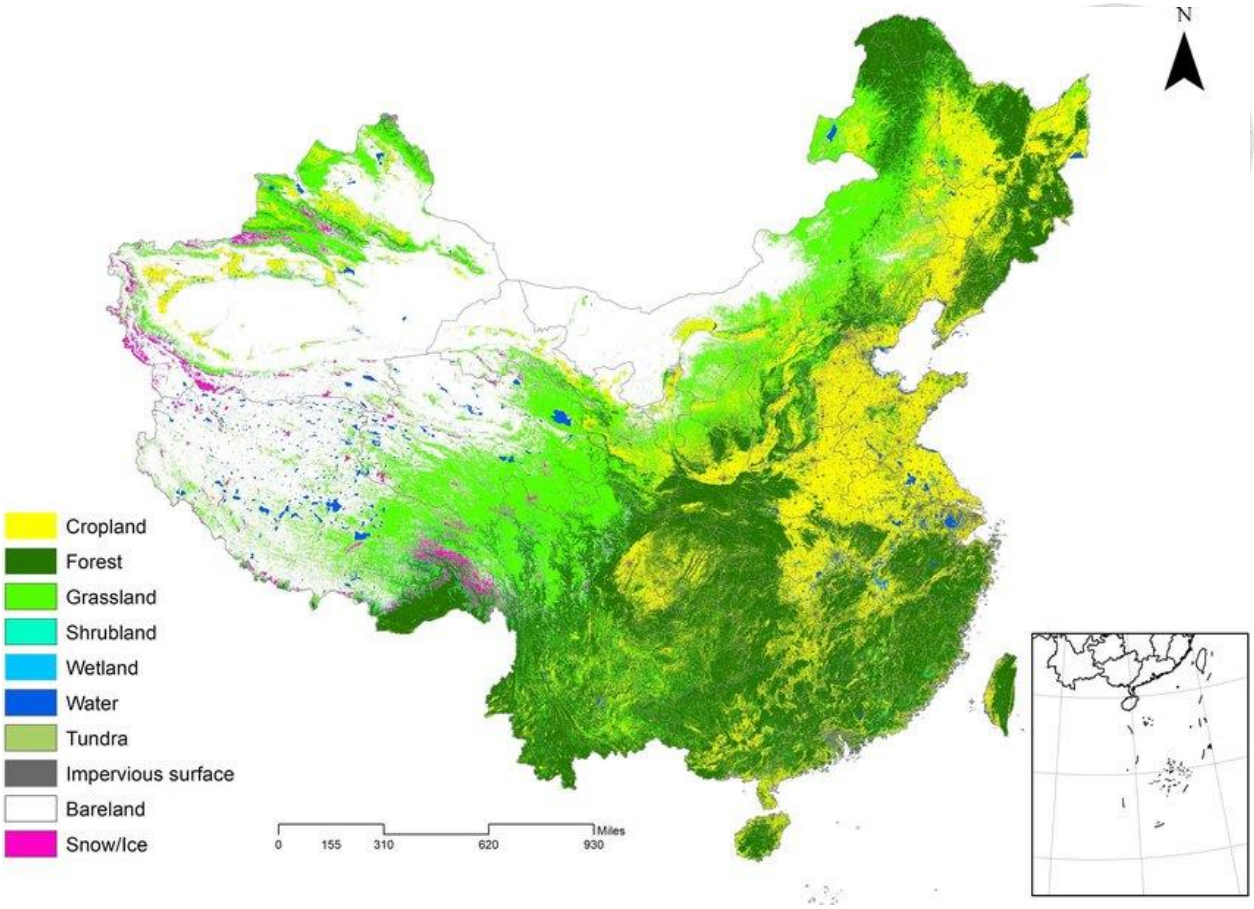

Figure 4: A map of terrain in China. Source: Duan et al., 2021

Despite China's colossal population and its rapid growth, it often faced cycles of tumult throughout its history, and for most of the past 200 years has been considered impoverished and undeveloped, despite its huge population and rapid growth. Food security was far from assured, and people often had to live off poverty-diets, even during more stable times, with about 90% of caloric intake coming from carbohydrate-heavy peasant crops such as rice, corn, and millet before the year 1900 (Nowakowski, 2015). During worse times, people starved en masse. There were at least 8 major famines in China during the 20th century alone, occurring between the years 1901 and 1962. With a usual length of about 2 years in this 61-year period, it means that

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China spent approximately one-fifth of this time period undergoing a famine somewhere within its territory (Li, 2008).

One famine in 1901 killed “only” 200,000 Chinese people in Shanxi province, and fewer in the province of Inner Mongolia and was caused by a drought. Another much more devastating famine struck from 1906-1907 in Anhui and Jiangsu provinces and was caused by flood from the previous season destroying planted crops before the harvest. This famine was the second worst of the 20th century and resulted in 20-25 million deaths (Kte’pi, 2011). Two famines occurred in the 1920s, one from 1920-21 and another from 1928-30. The earlier famine was caused by a severe drought in the north, but because of mass international aid and cooperation between competing Chinese governments during the Warlord Era, “only” 500,000 died. The latter famine was also caused by a drought as well as greater competition between the warlords and resulted in an estimated 10,000,000 deaths (Li, 1982).

Floods and shifts in the course of the Yellow River and Yangzi River would sporadically result in an approximate total of another 9,500,000 dead between 1930 and 1947. A pattern can be seen in almost all of these tragedies though. They are almost all caused by either drought in northern China, or flooding or shifting of paths of the Yellow River, with few of them caused by human error or pestilence. The natural geography of northern China was the greatest enemy against stable agriculture in the area, and the issue of food shortages were so widespread that in the early 1900s it was labeled as “The Land of Famine " by many international aid workers (Li, 2008).

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But later famines would not be caused by natural occurrences, at least not completely. In 1938 the Republic of China (then in control of the mainland) would intentionally flood a large section of western China to halt the Japanese invasion during World War 2. The flood would achieve its military objective but would cause great levels of destruction. The regions that were not denied to the Japanese, were also then destroyed by them. By 1942 there was vast destruction and persistent flood and a simultaneous drought and lack of rains in unflooded areas, and an additional swarm of locusts resulted in a year-long famine that killed about 700,000 people, mostly in Henan province. During the famine widespread cannibalism was reported (White, 1943).

As tragic and devastating these earlier famines were, none were as serious as the Great Chinese Famine from approximately 1958-1962 caused by Mao Ze Dong's "Great Leap Forward." The Great Chinese Famine's exact death toll is not known, especially because of the opaque nature of the Red Chinese (PRC) government that in power then and now obfuscating the data, but the range estimates go as low as "only" 15 million deaths to about 55 million, with a mean estimate being 35 million. This famine was unique in being entirely caused by government mismanagement. Evidence of this includes the fact that food production per region was actually positively associated with famine mortalities, as food would likely then be confiscated by authorities and inefficiently distributed. Other causes of the famine include over-reporting of food production, selling of what food there was onto the international market, centralized planning demanding high levels of steel production, and intentional ecological disruption causing swarms of locusts. While some regional minor droughts, such as one from 1960-1961 likely

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contributed to the famine, there is no way that they could be responsible for anything more than a small fraction of tens of millions of deaths that occurred (Smil, 1999; Meng et al., 2015).

Thankfully, since the tragic reign of Mao Ze Dong there have been no more mass-starvation events in China. Reversal of his farming policies coupled with decades of foreign investment and a slowing population growth have all contributed to a much more stable food situation in the People's Republic. However, its massive population and extensive ecological damage means that the country is still heavily reliant on imports. The country has been a net food importer by value since 2004, with its food self-sufficiency rate declining from over 93% to 65% in 2020 (Liu, 2023).

4.2 Current Status

China, like other nations mentioned in this study, is unable to solely sustain itself agriculturally, and relies on imports. China's reasons for this are somewhat unique compared to the others, however. Whereas Taiwan, South Korea, and Japan struggle because of a difficult geography, with little arable land and highly urbanized populations, China has vast amounts of arable land and highly productive river-basins for its agriculture. Additionally, China's diverse climates allow it to grow a variety of foods and have harvests at different times of the year, allowing for greater resilience and the highest caloric self-sufficiency of the four nations.

Despite these geographic boons, China's dependence on imports has increased substantially over the years. (Pao, 2021). One of the more obvious reasons for this is the growing

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wealth of China's population, with its rapid industrialization and growing significance in the world economy during the last several decades granting its citizens a whole new level of wealth. As a result of this many Chinese people are no longer content with poverty diets. For example, in 1940 2/3rds of corn grown in China was eaten, while today 60% is used for animal feed, 30% is for industrial purposes, and only 10% is eaten, with corn itself being viewed as a lower-class food. In general, grain consumption for an average rural Chinese person declined from over 250 kilograms a year in 1990 to around 175 kilograms in 2020. Meanwhile, consumption of other foods is increasing, such as meat and eggs. In 1990 a rural Chinese person on average only ate a measly 12 kilograms of meat annually and less than 3 kilograms of eggs, but this number increased to around 35 kilograms of meat and 12 kilograms of eggs by 2020 and is past 40 kilograms of meat and 13 kilograms of eggs for the urban population. Beef consumption has risen 48% since 2012, and in 2019 China became the world's largest beef market (Jiang, 2024; Nowakowski, 2015; Ye, Leeming, 2023).

Another painfully obvious reason for this reliance on foreign food providers is the catastrophic environmental decline that China has suffered during its rapid industrialization. China is one of the, if not the most, polluted country on the face of the Earth. Historical levels of arable land are unknown because of lack of record keeping, but in more recent years from 2009 to 2021 China has lost 6% of its arable land, an equivalent to over 75,000km^2, mostly because of expanding urbanization, attempt at afforestation, and of pollution (Stanway, 2021). In 2018 15.5% of all of China's groundwater was considered "Grade 5" pollution, meaning it was unsuitable for any use whatsoever, and a colossal 70.7% was rated Grade 4, meaning it was suitable only for industrial and irrigation uses. Grade 3 and below is considered suitable for

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drinking and consists of less than 15% of China's water supplies, with Grade 1, being natural sources of clean water, making up less than 2% (Schrag, 2020).

China's rampant air pollution also has resulted in decreased agricultural efficiency. China notoriously has some of the worst air quality in the world. This is not only unhealthy to people, but to plants and their important pollinators as well. It's estimated that even just moderate improvements in Chinese air quality could increase the country's corn yield by 7.8%, its rice yield by 4.1%, and its wheat yield by 3.5% (Liu, 2024). Soil pollution is also an extremely serious issue, not only because it can hamper plant growth, but what crops do grow can pass harmful pollutants onto the human populace.

Approximately 20% of China's arable land is contaminated by various chemicals, plastics, and heavy metals (Sun, et al., 2019). Despite this contamination, these areas are often still intensively used for agriculture, resulting in unsafe food. In 2013 the city of Guangzhou was racked by scandal when tests revealed that 44% of all rice products being sold in the city had unsafe levels of cadmium, a heavy metal that can cause cancer and organ damage. Much of the rice in this scandal was found to have come from Hunan province, a centrally located province important in much of China's logistics and shipping. Because of this scandal the government simply recommended people take note of which region that their rice comes from and to change them frequently so as to avoid toxic build-up, instead of combatting the actual source (Song, 2013). More recently in 2020 it was found that approximately 1/3rd of all rice produced in the Jin-Qu Basin in Sichuan was contaminated in both cadmium and lead (Guo, 2020). Additionally, China is the world's largest consumer of pesticides and fertilizers. While this does increase crop

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yields, the excessive usage of it has also resulted in soil and water contamination (Li et al., 2021).

What arable land China does have not only is afflicted with pollution, but much of it is eroding rapidly as well. General soil erosion caused by a mixture of over-use, water loss, desertification, soil salinization, and pasture over-grazing has affected almost 5.4 million km^2, or about 56% of China's entire landmass (Zhao, 2017). While this can be combated to a certain extent, such as by using more fertilizers, generalized desertification in some areas is not something that can be easily remedied. Since the 1980s desert has gone from approximately 20% of China's natural surface area, almost entirely in the northern Gobi Desert and the eastern Tarim Basin, to now about 30%. The causes for this are entirely anthropogenic, via methods such as overgrazing, water over-exploitation, and deforestation, which has led to ever-encroaching sand dunes. As a result, the Gobi Desert is the fastest growing desert on Earth (Browne, 2022; Rechtschaffen, 2017).

While the north of the country is frequently affected by drought, and now increasingly desertification, the south of the country routinely must deal with floods and damaging storms.in important agricultural provinces like Guanxi and Henan have been experiencing record rainfall as well as heat waves over the last several years. Subsequently, much farmland has been damaged and many people have lost their lives. For example, in 2021 flooding in Henan killed a minimum of 302 people, and in 2023 Henan farmers faced blight caused by excess humidity and heat that killed many fish and pigs further south. This destabilized food supply enough that the

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government decided to release its strategic reserves of pork and rice to keep prices low (Hong, 2023).

The actual levels of food security seem to fluctuate in China, with some years marked by decreases and others by increases. In 2021 China ranked 34th out of 113 countries on the Global Food Security Index and was one of the top 5 countries in terms of improvements, despite the general decades-long trend of it decreasing (Whiting, 2022). Similarly, its source of imports has also fluctuated quite a lot year-to-year. In 2003 the United States was China's largest source of imported food, followed by Argentina, Brazil, and Malaysia, but in 2017 the order shifted to Brazil and the United States as second, while Canada rose to third place after not even being in the top ten, followed closely by Australia in fourth and New Zealand in fifth. In 2003 Australia and New Zealand were in ninth and tenth place respectively. Meanwhile, Malaysia completely lost its place in the top ten (Schrag, 2020).

The imports from these countries have also grown remarkably; from the United States in 2003, its top supplier, were worth less than $4 billion, by 2010 this had risen to almost $14 billion, and in 2017 Brazil was the top supplier and valued at almost $23 billion. Interestingly, at no point during this time did the Russian Federation, a somewhat friendly country that borders China and is the world's largest exporter of wheat, enter into the top ten agricultural providers. Rather, the Peoples' Republic increased imports from Western countries, including the European Union, which became China's largest supplier of pork, the most commonly eaten meat in China. This dependence on imports for staple foods will likely continue into the foreseeable future, although what China imports from which country may continue to shift (Schrag, 2020).

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Other issues facing China are more systematic. Similar to Taiwan, the country is lacking large-scale agricultural industries, with many farms being small and decentralized, and family owned. This vast dispersion of agricultural resources and small-scale nature has hampered the spread of newer agricultural technologies and techniques and has prevented the development of economies of scale across the Chinese agricultural sector. It also encourages the farmers to try to maximize their own personal profits, usually by producing cash-crops that are either inedible or of little nutritional value for the resources put into them (Dong, et al., 2024).

Local administrations and central government bodies have also resulted in widespread inefficiency caused by their corruption and misrepresentation of data. For example a top official in the National Food and Strategic Reserves Administration was found guilty of corruption in 2022. Local administrators also frequently lie about agricultural output, hoping for promotions by making the data in their jurisdiction look better than it really is, which then causes confusion and misallocation, as well as the obvious shortages. Lack of trust in regulating bodies and food providers has promoted a sort of artificial demand for foreign imports, in that because of widespread pollution and lack of enforced safety regulations domestically Chinese consumers are more willing to purchase the same product from abroad that can be produced domestically, also hurting domestic producers and increasing reliance on foreign suppliers (Dong, et al., 2024).

Despite these challenges, China has long been determined to reach stable levels of food self-sufficiency. In 2003 the Communist Party launched the South-North Water Transfer Project, a mega-engineering project to transfer water from China’s water-abundant south to its dryer north

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via a complex system of canals and pumps. As of 2017 the north was receiving around 10km^3, and by 2030 its estimated that the north will be receiving somewhere around 15km^3 per year. There have been issues with this however, such as its immense cost and its environmental concerns. It's estimated that the project will actually result in a net loss in water because of increased evaporation, and so far, some of the diverted water from the Yangtze to the Yellow River was so polluted that it began to kill fish in the Yellow River (Ma, 2016; Mudie, 2013).

Since Xi Jinping rose to power in 2012 he has been launching campaigns to improve food security. His administration has been pushing for and approving more and more genetically modified crops to be used (Gu, 2023), and by combating consumer food waste that is equivalent to about 6% of the country's entire food production (although the actual food waste is at least double that when considering processing and retail loss) (Li et al., 2021; Wong, 2022). Loss of arable land has also been a significant concern, and the government has been attempting to combat this through various ways. One way has been by "reclaiming" land for agricultural uses, from current use as industrial or real-estate use, trying to improve efficiency by trying to develop farmland close to residential areas, as well as preserving existing arable land by encouraging crop rotation and leaving land fallow. An increase in safety regulations have also been noticeable over the last two decades, with the first wave of comprehensive food safety laws passed in 2009, however because of corruption and lack of enforcement many Chinese consumers still consider local foodstuffs as untrustworthy (Dong, et al., 2024).

Overall, the current status of China's food security is unstable, but holding. Despite rampant pollution, declining arable land, and water shortages, an increase of wealth and ability to

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import has led to an improvement of nutrition of the average Chinese citizen. But the current system is rather brittle, with multiple points of possible failure, and while the Chinese government seems to have acknowledged its weaknesses and is moving towards fixing them, it has much work left to do to properly address them.

4.3 Potential Future Challenges

China's food security is precarious. In fact, it is very unlikely to develop stable food security at all unless it can perform colossal environmental restoration and systematic changes. Such projects would have to include highly efficient use of current resources and land, while cleaning up polluted sources of water, air, and soil and revert desertified land to productive land. Furthermore, it would need to improve it at a systematic level, improving economy of scale and curbing corruption; even then it would be uncertain given China's colossal population that it has to feed. In the case of a crises, it seems unlikely that the Chinese Communist Party would adapt in a timely manner.

4.3.1 Environmental Degradation

The People's Republic of China has in recent years innovated on its infamous reputation for environmental destruction internationally. One of its most visible and controversial ways of doing this has been massive over-fishing. Fishing stocks within China's own waters are already long depleted and it has been having to send its fishing fleets across the world, sometimes violating other nation's waters, to still be able to catch anything. This has led to international

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disputes, but also has resulted in over-fishing and environmental destruction across the world and makes China reliant on the health of foreign waters, not just its own (Meyers, et al., 2022). It's estimated that even with this internationalized strategy, China's consumption of seafood with outstrip its fleet production by 2030, forcing it to either adapt in ways such as adopting aquaculture, changing consumption patterns, or paying a premium on imports from globally depleted fish stocks (Crona, et al., 2020).

Loss of arable land and desertification is of course also a pressing issue. If this issue is not mitigated, it could spiral to catastrophic levels. As previously mentioned, about 56% of China's entire landmass is afflicted by some level of soil erosion or pollution (Zhao, 2017), and between 2009 to 2021 China has lost 6% of its arable land, which is about 0.5% a year (Stanway, 2021). At this rate, China could reach catastrophe in about a decade; the Xi Jinping's administration has already assessed that China at minimum requires 120 million hectares of arable land, and currently this number stands at only 127 million hectares (Textor, 2024). The amount of arable land is likely overstated as well, as much of the land is polluted, and the "reclaiming" of arable land from previous uses such as industry or real-estate would be complicated, considering left over pollution and top soil erosion from the process of building and development (Dong, et al., 2024).

Water shortages are also a looming threat in China. Only 2% of its water supplies are unpolluted and 70% are severely polluted, and just barely suitable for irrigation usage (Schrag, 2020). Currently China has only 6% of the world's freshwater, much of which is polluted, and almost 18% of the world's population. Already its renewable water resources per capita are only

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at about 2000 cubic meters, which is 75% less than the global average, and half of what it was in the 1960's (Leung, 2023). The issue of drought will also affect different regions of China very differently. Parts of the south are so wet they are borderline immune to drought, whereas in the north water shortages are a persistent issue, and in regions around the Gobi Desert and the Tarim Basin water shortages have the potential to be quite extreme. Already the North China Plain's water supply is half of what the United Nations would consider to be acute water scarcity (Collins, Reddy, 2023).

Even in the case of China managing to supply enough food for its population domestically, it cannot be overstressed by the severity of the country's pollution. The combination of the air, water, and soil pollution not only harms food production, but what food is produced can have disastrous health consequences. Heavy metals, carcinogens, microplastics, chemical enhancers and preservatives, all of these will have deleterious effects on the health of anyone who must eat food produced in China long-term. Not only would this hurt the reputation and markets for domestic food producers, but it would give a new meaning to the concept of food security, and the extremely prevalent contaminants in Chinese food may soon lead to lower life expectancy, widespread health complications and overstressed healthcare infrastructure, and generally lower productivity.

4.3.2 Regional Conflict

In the case of regional conflict, there are a few possible causes for China to be directly involved in. One of the regional conflicts could be with India over their myriads of border

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disputes in the Himalayan region. In the case of this conflict China would likely not suffer any major setbacks to food production or food safety. The border areas between China and India are not suitable for agriculture and are quite far away from China's agricultural heartland. The only realistic threat this could cause to China would likely be damage to any dams around the area on the Tibetan Plateau which would empty many reservoirs and possibly flood downstream farms, but even these are quite some distance from the potential front line.

Otherwise, the most likely regional conflict would come to China's eastern waters, specifically around Taiwan and the South China Sea, quite likely caused by China itself. Should such a conflict arise many shipping routes to and from China would be completely disrupted and would leave China's ports isolated from the world. In this situation China would be unable to import goods it currently relies on such as animal feed, beef, and oils, but would still likely be able to fulfill its raw caloric needs by shifting production from cash-crops to food crops. Furthermore, while China does not currently import much food overland, it does share a border with Russia, the world's third largest wheat producer and another agricultural giant, and it does have the potential to shift in this direction to make up for any shortfalls.

4.3.3 International Disruption

China is somewhat susceptible to general international disruption, but its variety of import partners creates a rather resilient system. Disruptions to specific goods such as meat, animal feed, fish, and certain grains and vegetables could create some shortages and price increases. However, no one crisis would lead to major disruptions in overall Chinese food security.

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For instance, a crisis in South America, where China gets most of its soybeans, would deprive it of important animal feed, but it still imports a large fraction from the United States and North America. Meanwhile, it continues to get most of its meat imports from North America, Europe, and Oceania, so a crisis, so if it is unable to import feed from South America, it will still have direct meat imports. Should a crisis emerge in North America, Europe, or Oceania, it still has the other two sources to import from (Schrag, 2020).

When the war in Ukraine intensified in 2022, causing massive international food shortages and price increases, China was largely unaffected. China, despite importing almost 30% of all its corn from Ukraine and 30% of its fertilizer from Russia, and being Ukraine's largest buyer of corn, did not see significant price increases or any shortages as the conflict and disruption affected most of the world (Nakazawa, 2022). However, this is largely because the Chinese government began releasing strategic stores of grain to keep prices down and avoid any shortages, which is not something it would be able to do indefinitely without changing its main supplier. This does show that China is prepared for disruptions and can get through them largely unaffected so long as they are able to source from a new supplier, increase domestic production, or wait until the situation stabilizes. Although if crisis emerged in multiple places in the world and were persistent, it could create serious issues in China because of its overall dependency on imports, but then again any country reliant on imports would struggle if multiple different crises ravaged its different suppliers around the world. (Cheng, 2022).

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5. Japan

5.1 History, Geography, and Demographics

Japan is an archipelagic nation consisting of many islands off Asia's eastern fringe. Its four major islands are Hokkaido, Honshu, Shikoku, and Kyushu running north-south. Besides these four major islands Japan consists of about 14,000 more small islands and islets, 260 of which are inhabited (Kojo, 2023). In total it has a land surface area of 364,485km^2 and water area of 13,430km^2, making it the 63rd largest nation in the world and the 4th largest island nation. In total it has about 4 million hectares of arable land, or about 40,000km^2, comprising just over 11% of its land area, or just over threefold the arable land of Taiwan despite being ten-times larger in land area ("Japan," Central Intelligence Agency).

Japan has been continuously inhabited for many thousands of years, and permanent settlements began to form between 13,000 and 11,000 years ago. These early communities survived on a mixture of hunting, fishing, and gathering, and about 4,000 years ago agriculture began to develop and population density rose. By 3,000 years ago crops such as hemp, millet, and rice were brought over from the Asian mainland and became common crops throughout the archipelago. Some hundreds of years after that, cultural newcomers from what is Korea today brought even more crops and technologies, such as gourds, beans, peaches, persimmons, wheat, and soybeans, as well as bronze-working and drainage methods for rice paddy fields, which led to a greater shift from millet to rice as the main staple crop, with these new methods and crops moving slowly from Japan's south to north over hundreds of years (Cartwright, 2024; Mellanby, et al., 2024).

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Like other rice-based cultures, the Japanese benefitted from the method of double-cropping, allowing for two harvests a year (Ferriera, Critelli, 2023). Additionally, Japan's geography gave it some agricultural resilience. The far north and far south of Japan have very different climates, with the south being able to grow more exotic crops and fruits, such as sugar cane and peaches, thanks to its sub-tropical climate, while the north relied on hardier crops such as wheat and beans. This diversity allowed for a more varied diet and redundancy in case of crop blights or other causes of shortages (Cartwright, 2024; Mellanby, et al., 2024).

Socio-cultural aspects also had a significant effect on the Japanese diet. In the 6th century A.D. Buddhism was introduced to Japan, a religion in which the killing of animals is considered taboo and an act of last resort, with vegetarianism being espoused as moral, although in Japanese Buddhism certain game meats and fish were allowed. As a result, the Japanese developed a diet heavily reliant on vegetables and fish. Natural geography also contributed to this; Japan is a very mountainous country with little flat land. Land intensive forms of agriculture, such as cattle ranching, were not favored and non-seafood meats were often seen as a luxury. The shortage of flat-land also resulted in population and agricultural centers developing far from one another in rare and much-coveted coastal plains, such as Tokyo, Osaka, and Tsushima (Cartwright, 2024).

During the Age of Exploration, like much of the world, Japan was introduced to a myriad of crops from the New World, such as potatoes and corn, the former being especially important to the colder northern parts of Japan. Japan was rather isolationist and conservative, limiting the initial spread of some of these crops, but by the time they were introduced Japan was

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experiencing rapid population growth. The Japanese population almost doubled to over 27 million people between 1600 and 1700 and then nearly doubled again by 1900. From 1900 to 2000 rapid technological development such as pesticides, herbicides, and the ability to import food tripled the population to over 127 million people (O'Neil, 2006).

The Meiji Restoration was a particularly important period in Japanese history that began in the 19th century. It was a period of rapid political, economic, and technological reform that propelled Japan into being the only industrialized nation in the region and allowed it to compete with European powers internationally. This time resulted in a massive population boom, as child mortality rates plummeted, and overseas colonies contributed to rapid economic development. Population growth stagnated during the Second World War, but the population went through a colossal boom again, as the post-war "economic miracle" would see Japan becoming one of the wealthiest countries in the world, having the second largest economy until being surpassed by China in 1978. Population growth slowed in the 1980s, and Japan grew to have one of the oldest populations in the world. The population peaked in 2008 at just over 128 million, but has fallen each year since then (O'Neil, 2024).

This rapid economic and population growth resulted in a rather unique issue in Japan. Because the population huddled in sporadic and valuable coastal plains, which was some of the only land suitable for widespread agriculture among the many mountain chains, it often led to a clash of interests between the usage of land for agriculture against for real estate and industry. For instance, Tokyo is the world's most populous metropolitan area at 40 million people, or about 1/3rd of the Japanese population. As land is in high demand here while also lacking in

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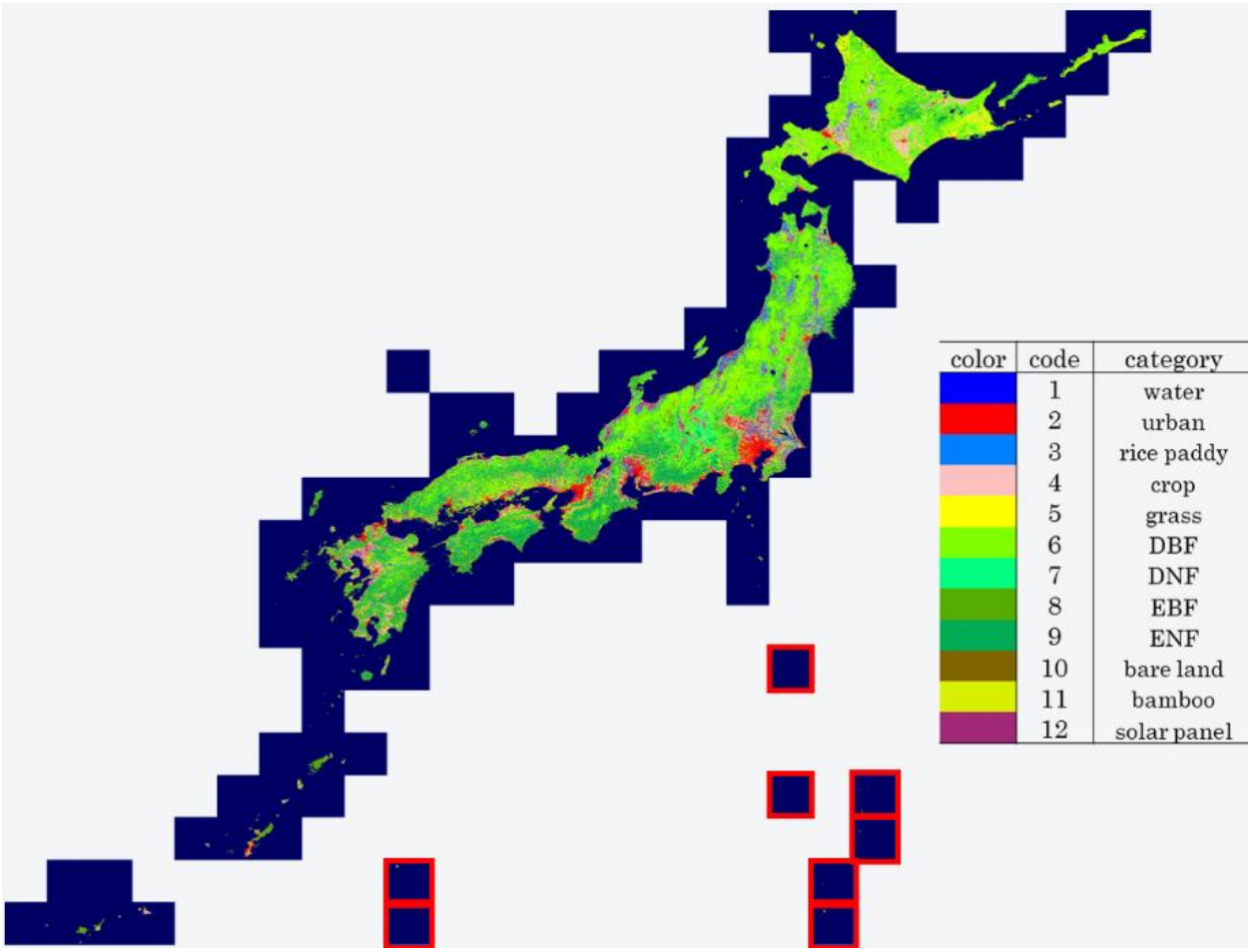
quantity, it is distributed to industry and real estate rather than crop production, leading to little arable land near metropolitan areas getting used for agriculture and generally lower production. Then, what crops are grown must then be transported to the metropolitan areas, decreasing the efficiency of distribution.



- *Figure 5: a land coverage map of Japan (DBF = deciduous broad-leaf forest; DNF = deciduous needle-leaf forest; EBF = evergreen broad-leaf forest; ENF = evergreen needle-leaf forest). Source: Advanced Land Observing Satellite, 2021.*

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Japan also has one of the highest urbanization rates in the world. According to the world bank 92% of Japanese people live in urban areas, primarily in cities living in the scarce coastal plains. Tokyo alone has 1/3rd of the population, the Kyoto-Osaka-Kobe metropolitan area has almost 20 million inhabitants, Nagoya has nearly 10 million, Fukuoka 5.5 million, and Shizuoka has 2.8 million. These are the five largest metropolitan areas in Japan, and together have just over 74 million inhabitants, or 60% of Japan's total population, and all of them, except for Fukuoka, are on eastern Honshu. Naturally, this leaves very little of the population in rural areas where most agriculture is performed, and Japan's population of farmers was only 1.36 million, and declining, in 2020, with the average age being 67.8 years old, and the average size of a farm was only 3.1 hectares (*Japan Agri News*, 2020).

In the past, Japan did actually manage to achieve relative stability in their food supply at multiple points in its past or managed to achieve enough via fishing or imports to make up for any crop failures. The last famine in Japan was the Great Tenmei Famine of the late 18th century, and a lack of arable land oof the home islands pushed the Japanese to expand their empire into places such as Korea and Taiwan. Even before the Second World War the Japanese Empire was producing just barely enough food to keep its population healthy, and that was only accomplished in large part because of imports from their new subjects in their colonies. Given the destruction that Japan faces in the Second World War, its loss of many of its young men, as well as its most productive colonial lands, Japan faced food shortages in the late 1940s, but was able to get by on simple rationing with American help (Donnelly, 1978).

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During the 1950s Japan was experiencing rapid population growth following a baby boom and the expulsion of overseas Japanese, while its economy also was managing to recover rapidly. This created not only an increased demand for food, but also shifting food tastes towards a more Western-style diet, as is common in many parts of countries in Asia that grow more affluent, which then requires even greater imports for non-traditional foods. Of course, as affluence grew and more young people moved to the cities for work, the number of people taking up agriculture as a profession declined. However, this was not much of a concern for the Japanese public or government, as the rapidly expanding economy ensured that they would be able to buy food from abroad, and in fact almost one-tenth of all agricultural goods sold on the international market was going to Japan, and Japanese calorie self-sufficiency finally peaked in the 1960's at 90%, before entering into an unerring decline, falling to 72% in 1972 and then farther down to 54% in terms of total calories, the lowest of any industrialized country. Since then, this trend has only continued (Donnelly, 1978).

5.2 Current Status

Japan is heavily reliant on food imports; the country's food self-sufficiency rate is at only 38%, the lowest of any industrialized nation. Wheat, soybeans, and edible oils are the most essential yet under-produced goods in the country, with Japan importing 83%, 78%, and 97% of these products respectively. Livestock is over 80% imported, fruits are about 65%, only seafood, vegetables, and rice being less than 50%, at about 45%, 24%, and finally 1%, respectively. Obviously, the only agricultural good that Japan is truly self-sufficient in is rice, which the government prioritizes as a strategic resource (Goedde et al., 2017; Lewis, Inagaki; 2022).

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This is technically an improvement from 2020 when it hit its lowest caloric self-sufficiency level in its recorded history at only 37%. However, this marginal increase of only 1% is mainly attributed to a slight shift in Japanese consumption in favor of rice, which is locally grown, compared to some other imports such as wheat, rather than any sort of structural improvements to its agricultural sector (Japan Times, 2023).

Many of the issues that have led to the current record-low levels of self-sufficiency are the result of many long-running trends that have gone unalleviated. As previously mentioned, Japan is naturally geographically challenged with its reliance on population clusters in and around essential coastal plains, leading to a premium on flat land which leads farmers to compete with high-value real estate and industrial sectors. The population of farmers has been aging rapidly, with the average age being almost 68 and managing small farms of only about 3 square kilometers, as young people prefer to seek work in urban centers. The consumption habits of the Japanese have also become much more Westernized, preferring more land-intensive food choices such as beef and wheat rather than traditional foods such as rice that are more labor-intensive but produce more per area, meaning that the consumers of Japan simply have higher preference for imports than domestic foods. One of the few advantages that Japan has is that the food goods that it does produce tend to be higher value than imports, so despite Japan only reaching 38% of its calories needed for self-sufficiency, it produces 58% of it in terms of value, although from a perspective of strategic stability of its agricultural this doesn't matter so much. As long as a locally produced kilogram of beef has the same calories and protein of a cheaper imported one, this advantage does little more than provide incentive for some Japanese producers to not totally abandon agricultural production (McMeekin, 2023).

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In part, all of this is by choice. The Japanese people and government have been well-aware of these issues for decades and have only adopted modest policies to slow the decline in self-sufficiency or protect only rice producers with few protections for other kinds of farmers. This was actually a rather wise move, as it allowed Japan to lean into and prioritize its higher-value industries that made it as wealthy as it is, which it can then use to import cheaper foods from more agriculturally efficient countries like the United States. Thus, this specialization away from agriculture towards other industries has helped promote Japanese economic growth and lower the cost of living for its citizens (Donnelly, 1978).

Japan relies on a few major countries for its agricultural imports. By calories, Japan imports 22% from the United States, 11% from Australia, then Canada at 9% for its top 3 importers, combined being 42%, then followed by Brazil, Malaysia, the European Union, and finally China, making up the remaining 18% combined, as Japan produces 38% on its own (Nippon, 2023). Apart from Malaysia and China as minor suppliers, obviously the rest of its import sources are from distant countries, primarily Western ones.

Part of this complacency towards increasing dependence on foreign markets has also been in-part because of an ideological view that Japan should be completely self-sufficient in production of rice. When the issue of food security does arise, a common response from Japanese decision makers is that the Japanese can always eat more rice as a substitute in the case of any shocks. This is unrealistic however, as if there were a major shock in food supply and it

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was necessary for people to shift towards eating more rice, the existing supply is simply not there. If the Japanese were to completely abandon wheat imports in favor of domestically produced rice then rice production would have to be increased by a whopping 62%. Even if this were accomplished, Japanese consumers suffer the highest rice prices in the world, which would certainly hamper living standards, and the increase in demand would lead to an increase in price of rice, which would then incentivize substitution of it via cheaper imports once again (Lewis, Inagaki, 2022).

This system of import reliance while focusing on more productive industries has worked historically for Japan, but in recent years this system has become much more strained. This system relies heavily on the internationalized world and foreign crises can impact Japan very negatively. For example, the recent crisis in Ukraine and a global rise in energy prices has reintroduced the issue of self-sufficiency to Japan. In 2022 alone Japanese consumers saw a price increase of almost 50% for food, as international wheat prices sky-rocketed following the Russian invasion of Ukraine, as America's energy production tanked and global prices rose, and as the Japanese yen has weakened against the dollar, making the cost of imports relatively more expensive (Lewis, Inagaki; 2022).

Additionally, many sanctions on Russia have also disrupted Japanese markets. Japan is quite distant from many energy sources, and Russia was one of its energy providers, which ended after the invasion of Ukraine. Furthermore, Japan was heavily reliant on Russian fertilizers, which it also now has no access to; Japan is wealthy though and was able to shift suppliers away from Russia to countries like Canada and Morocco. Still, this represents the

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weaknesses of the Japanese reliance on globalization for its sustenance: if Canada or Morocco where to go through some crises or instability next, Japan would have to shift again, experiencing shocks as it constantly tries to correct them (Lewis, Inagaki; 2022).

The Japanese government now seems aware of the weaknesses in its strategy and has begun some programs to increase domestic production. These programs include, in a classic Japanese way, to increase efficiency through technologies such as robotics. Robotic wheelbarrows to help aging farmers to improve technologies to distribute migrant workers are just two of them. Other solutions include trying to produce algae suitable for animal feed to reduce reliance on soybean exports from places like the United States and Brazil and moving towards renewable energy to avoid future energy shocks. A more low-tech method has also been to try to encourage more young people to pick up farming (Lewis, Inagaki; 2022).

Naturally, as previously mentioned, the Japanese also emphasize domestic rice production quite a lot, but it is limited by lack of farmland. For Japan to replace wheat and increase production over 60% it would require 900,000 more hectares of farmland, meanwhile the government estimates that there is only 90,000 unused hectares, meaning it could increase production by only 6% without also causing other forms of domestic agricultural production to decrease by shifting to rice. Increasing rice productivity would also only help marginally, with average increase in productivity of rice per hectare at less than 0.2% per year between 2000 and 2020, and at this rate would require 200 years to increase production to such levels (Lewis, Inagaki; 2022).

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The issue of a lack of farmers is also a crippling issue that would require a titanic effort to overcome. The number of people working in agriculture is shrinking, from 2 million agricultural workers in 2015, to less than 1.5 million today, a decline of 25% in less than a decade. This is because many farmers are aging and dying, urbanization, and the large upfront investment in becoming a farmer, which is intimidating to many people considering Japan has been experiencing economic stagnation for about three decades. Additionally, while many countries supplement their declining agricultural worker base with mass influxes of migrant labor, in Japan mass immigration is extremely unpopular politically, and so is unlikely to be accomplished (Yoshikawa, 2022).

Increasing domestic food production is now a political topic in Japan. In 2020 Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) released the document "2020 Basic Plan for Food, Agriculture, and Rural Areas" and outlined many of the mentioned issues and plans to correct them and plans to increase caloric self-sufficiency to 45% and self-sufficiency by value to 75% by 2030. This would require a caloric production increase of 7-8% with just 5 more years to accomplish this goal. A 7% increase over a decade sounds plausible at face-value, but considering the myriads of problems Japan's agricultural sector is facing, especially its declining labor force, this is very unlikely to be accomplished, at least not without mass migration (Yoshikawa, 2022).

5.3 Potential Future Challenges

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Japan has the lowest caloric self-sufficiency rating of any industrialized nation, and it will be unlikely to lose this title. It faces many issues, both systematic ones and those from its physical geography. It has plans to revitalize abandoned farmlands and to increase the number of younger workers in the agricultural sector, as well as to introduce smart technologies. These measures may improve its situation but given possible issues of the near-future the nation's self-sufficiency may continue to deteriorate.

5.3.1 Environmental Degradation

Japan has a relatively pristine environment, especially as its extremely high urbanization rates leave much of the country unmolested by human habitation or industry. Soil erosion has been a historical issue for the country, and since the 1950s the government has been promoting practices to mitigate this, to much success. The soil erosion was largely caused by water erosion on the terraced and sloped farms on the rural hills, and landscaping programs to be more resistant to this via better drainage techniques and resistant slopes have become standard practice, along with other practices such as mulching, strip-cropping, and multi-cropping to maintain fertility (Shiono, 2013).

Japan's greatest environmental concern is climate change. Increased rainfall and extreme weather are predicted to increase soil erosion by rainfall, as well as causing direct damage to farmland. More alarmingly, as the vast majority of the population and fertile land is along coastal plains, rising sea level could seriously reduce the amount of arable land, both by submergence and in-flow of salt water into aquifers (Shiono, 2013).

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Other concerns of climate change include effects include a of high-quality rice and an increase in the occurrence of pests and weeds. Japan is one of the few countries for whom climate change is not all bad though. Japan's north is very cold and not suitable for much agriculture, yet its northernmost island of Hokkaido is the flattest of Japan's islands. Should global temperatures rise there would be a northward shift in suitable climates for agriculture, and Japan may gain enough arable land to make up for what is lost, or even be able to increase it (Satake, Kura, 2021).

5.3.2 Regional Conflict

Japan has the unique honor of being perhaps the only country that has border disputes with literally all of its neighbors: Russia, South Korea, Taiwan, and China. It is also an important American ally and Western partner in the region, and should any conflict arise, Japan would likely be involved in some way.

Despite its own border disputes, it's unlikely that a regional conflict would arise because of any of them except for its dispute with China over the Senkaku Islands. Its disputes with Russia over the Kuril Islands remain tense but stable for decades, its dispute with South Korea over the Liancourt Rocks is largely symbolic, and it has an agreement to share fishing waters in disputed areas with Taiwan. Should any conflict arise in the region involving or seriously affecting Japan, it would almost certainly be towards its southwest towards Taiwan and the South China Sea or a conflict on the Korean Peninsula.

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In the case of such a conflict in the South China Sea Japan would be challenged in that the food imports from countries such as Southeast Asia, Europe, and Oceania may be disrupted. However, most of its food imports are taken in from its east, from across the Pacific from the United States, Canada, and Brazil, such that most of its imports would be unmolested. In the case of a conflict isolated to the Korean Peninsula, Japan would be largely unaffected agriculturally. Should Japan somehow get involved in a full-scale war, it would not be possible for any country to blockade the home islands without overwhelming naval superiority in the Pacific, and as the largest naval power, the United States, is an ally, this would also not be something to concern the Japanese.

Thus, the largest way regional conflict could arise in Japan is by removing its options to import food from its southeast, which only makes up a fraction of total imports. Therefor Japan's food security would remain largely the same in such a case.

5.3.3 International Disruption

Japan's globalized economy is quite susceptible to international disruption. As was seen in recent years with many disruptions, such as COVID-19 and the war in Ukraine, Japan was subject to price increases as it struggled to secure its imports. Japan only has as much security as it can buy food from abroad, so crises in certain regions, such as Eastern Europe, can result in things like wheat and fertilizer shortages. Similarly, any sort of disruption in North or South America would devastate things like corn, pork, and soybean imports (Goedde et al., 2017; Lewis, Inagaki; 2022).

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The disruption does not necessarily even have to be military or global. Such things as a decrease in value of the Japanese yen can increase the cost of many foods, and foreign economic collapses or environmental issues, say a widespread bankruptcy of farmers or a drought, could hurt Japanese access to food. It's this international nature that is perhaps the greatest liability to the Japanese system. Future predictions of threats to Japan's access to food include one of the major concerns to be the opposite of disruptions, that is global economic development. As other countries modernize and economically develop, they will have more economic purchasing power while Japan stagnates, leading Japan into a bidding war for necessities (Goedde et al., 2017).

6. South Korea

6.1 History, Geography, and Demographics

The Republic of Korea, or South Korea going forward, is a modestly sized country of approximately 100,000km^2, which makes it the 107th largest country in the world, being smaller than Guatemala but a little larger than Hungary. The country is ethnically homogenous, and its landscape consists largely of mountains, with about three-quarters of the country dominated by mountain ranges, while its west and south hold most of the 30% of land that is lowlands. In terms of climate, it varies slightly, with most of the country having a humid continental climate and a humid subtropical one along the southern and eastern most coastlines.

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Agriculture first developed in South Korea in the Paleolithic era, where rice and millet became staple crops. Much later in the Middle Ages Korean governments launched programs to introduce new crops to the lands from abroad, bringing in things like ginseng and tea from China, and cotton from Vietnam. During Joseon times, the last period of Korean independence until the Cold War, the administrations further encouraged development of new agricultural methods. From the 15th to 18th century a myriad of new agricultural techniques and technologies were developed and spread throughout Korea. Transplanting, new fertilization and irrigation methods, and double cropping increased many yields. As a result of this proactive approach to agricultural development, food supplies were sufficient, and famines were relatively rare (Jaehoon, 2017; Jeong-Sup, 2003).

From 1592-98 there were famines during the Imjin Wars when Japan invaded the peninsula, and again a serious one from 1626-1627, but there weren't any others on the Korean Peninsula until North Korea in the 1990s (Kim, 2020). There were issues of persistent food shortages and regular starvation on the Peninsula during Japanese rule from 1910 to 1945, but this was not because of agricultural issues, but rather Japanese exploitation, favoring Japanese colonial farmers and sending much of the peninsula's food crops back to the home islands. Many Korean farmers ended up deprived of land, and either moved to Manchuria or moved to the Japanese home islands to be laborers. Despite this, between 1910 and 1945 the population of what is today South Korea increased from 10 million to over 17 million as the Japanese introduced more technically advanced farming techniques (Savada, Shaw, 1990).

After the Second World War much of East Asia was devastated and South Korea was given independence as a sovereign country. It went through serious reforms, such as land

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redistribution from rich Japanese colonialists to local South Korean farmers. In 1961 South Korea also established the National Agricultural Cooperative Federation, an organization to promote agricultural prosperity in ways such as financing, insurance, banking, and agricultural price controls. For some time after its establishment grain prices were capped to prevent inflation, compete with imports, and keep food cheap for impoverished laborers (*Nonghyup*, 2022).

For the rest of the 20th century South Korea increasingly liberalized and industrialized, growing more and more prosperous and with higher rates of urbanization. Food production always had to be supplemented by imports at this time. In 1996 South Korea reached self-sufficiency in rice after extensive mechanization, its most important staple crop, but this has declined since. Like surrounding countries, agriculture and fishing as a portion of GDP and economic growth has declined as other sectors such as manufacturing and services have surged, giving it little financial incentive to expand this sector further (Jeong et al., 2020).

As of today, South Korea has a population of 41 million people, with a very high urbanization rate of 92%, the same as Japan. About 10 million people live in the capital of Seoul, followed by Busan at 3.5 million, Incheon at 3 million, Daegu at 2.5 million, and Daejon at 1.5 million, and these five largest cities make up about 43% of the entire population, and the next 5 largest make up an addition 11%, giving 54% of the country's population to its top 10 metropolitan areas. The northwest coast near Seoul is the most densely populated, followed by the southeastern coastline (Wang, Anderson, 2020).

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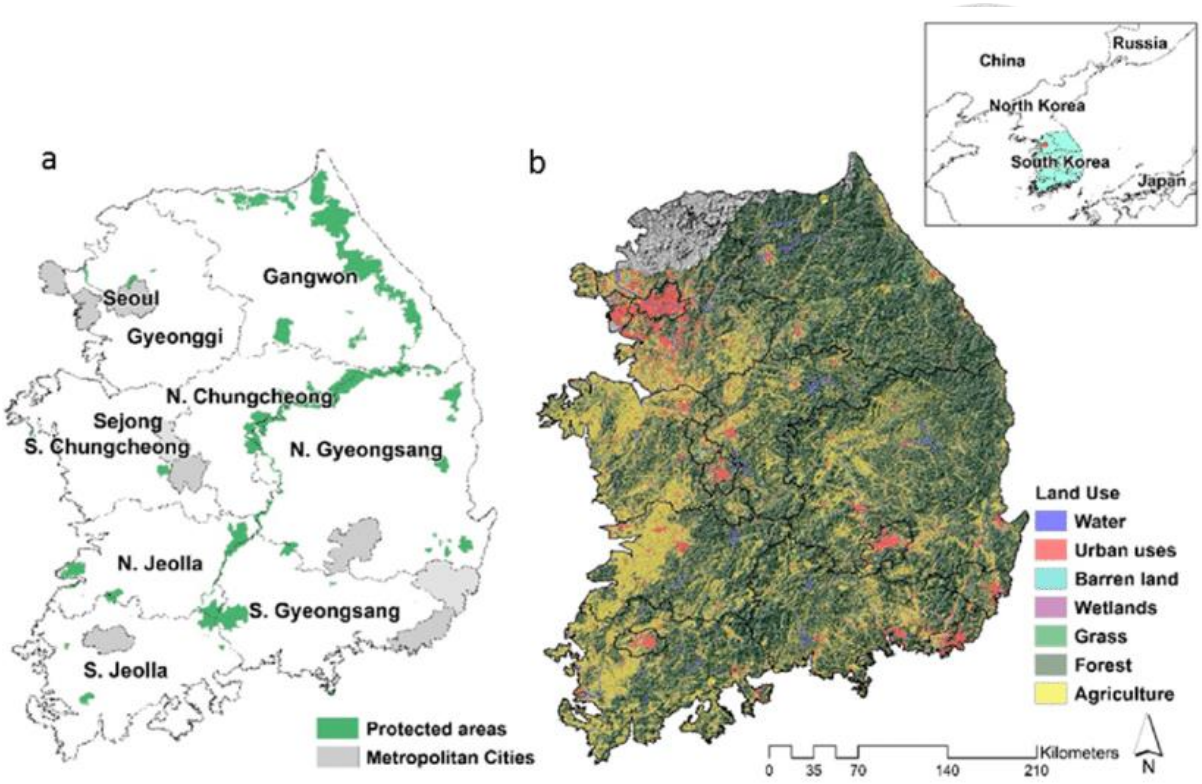

Figure 6: Land usage of South Korea. Source: Choe, Thorne, 2017

South Korea is also one of the countries on earth with the highest population density. It is estimated that South Korea has a massive 530 people per square kilometer, higher than the Netherlands at 424 and India's at 435, but less than Taiwan's at 676, being the 15th most densely populated country in the world. However, as about 70% of South Korea is mountainous, the effective population density is much higher. For instance, Seoul, the capital, has a population density of 16,000 per square kilometer, more than twice of Tokyo's 7,330 (Savada, Shaw, 1992).

This population density may begin to decline though, as South Korea has some of the lowest fertility rates in the world. Total fertility rate fell below 2.1, the rate required to maintain a population, in the 1980s, fell below 1.5 by 2000, and reached below 1 in 2018. In 2020 it did

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have the lowest rate in the world at 0.84, and Seoul had a rate of 0.64, possibly the lowest anywhere on earth. As a result, it's estimated that South Korea's population has already peaked, and will reach below 50 million by 2040 and down to 40 million by 2060 (Lee, Botto, 2021).

South Korea's population is rapidly aging, which can be seen in its agricultural sector. Almost half of all farmers are 65 years or older, which is the retirement age of South Korea. This is quite similar to other East Asian countries that have elderly farmers, and similarly South Korean farms tend to be very small. The average South Korean farmer has access to a small 1.4 hectares of land, smaller than even Japan's (Gaille, 2018).

This combination of an aging workforce, increased urbanization, as well as dietary shifts away from rice towards a Westernized pallet, has led to consistent decline in the use of arable land. About half of South Korea's arable land is actively used for agricultural production, and half of that is consistently used for rice production, but this has been declining consistently for years, at a rate of about 1% per year. The total amount of arable land has also gradually been declining at a similar rate as much of it is used for urban and industrial development. Furthermore, what land cultivated for non-rice grains is decreasing, with farmers instead focusing on cash-crops such as fruits and certain vegetables, which provide fewer calories per area than grains goods (National Platform for Business Development, 2021).

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6.2 Current Status

South Korea has a low rate of self-sufficiency, at only 44% of its caloric needs, down from 50% in 2015. When it comes to grain, often one of the cheapest and efficient form of raw calories, South Korea has a self-sufficiency rate of only 20%, with much of this being rice while wheat was at a microscopic 1% (Bhadra et al., 2023).

By value, in 2021 South Korea's largest food supplier was the United States at 22%, followed by China at 15%, Brazil at 7%, Australia, Thailand, and Vietnam each at 5%, Russia, Germany, and France at 3% each, and Italy at just over 2%. These top-10 suppliers for South Korea combined make up 70% of all imports. Out of them, two of them are in the Americas, three are in Asia (not including Russia), one is in Oceania, and four are European. In 2022 the total agricultural imports were valued at US$46.8 billion (*Korea, Rep. Food Products Imports by country 2021*).

South Korea currently stands in the top 10 food importing countries in the world and is the sixth largest importer of agricultural goods from the United States, down from fifth just a few years ago. An interesting quirk of its food imports though is that it seems to heavily favor processed, pre-made foods. While beef and corn were the two largest imports, the third was soups and other pre-packaged products, and processed foods make up 45% of all South Korean imports. Additionally, like other Asian countries the Westernization of its pallet has led to large quantities of meat and wheat imports in general. A recent reduction in import tariffs on goods such as pork and sugar will also likely contribute to the trend of importing most goods (National Platform for Business Development, 2021).

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Domestic production has continued to decline over the years, and South Korea is fully self-sufficient in nothing agriculturally, although it is able to produce 92% of the rice it consumes, but this is only with the titanic contribution of about half of all its agricultural land being used for it and 82% of its agricultural workforce. Between 1990 and 2009 rice production fell from over 5.6 million metric tons to 4.9 million, a decrease of 12.5%, and in 2023 this had fallen to 3.7 million metric tons, a total decrease of 34% since 1990. Meanwhile the number of hectares dedicated to rice fell from 1.25 million to 924,000 to 711,000 hectares in the same period, a decline of 44% in total. Despite the massive decrease in area used for rice production, the amount of rice produced has not decreased by as much, which is because South Korea has been managing to increase rice production efficiency year-on-year per hectare, averaging about 1.9% increase per hectare between 2018 and 2023 (Gaille, 2018; Seok-Min, 2023).

Like Japan, in part, all of this is by choice. South Korea has been well-aware of the decline in self-sufficiency over the decades, but as a rapidly industrializing nation, and now one amongst the wealthy nations of the world, primary level production wasn't and isn't one of the sectors emphasized, instead moving towards high-tech and industry. Meanwhile, with its wealth it can then import cheaper foods from more agriculturally efficient countries like the United States (Donnelly, 1978).

In very recent times South Korea has also struggled with drought. For example, the Dongbok Dam Reservoir that stores a lot of water for the country's southwest experienced only 800 millimeters of rainfall in 2021, about 60% less than usual. The issue became so extreme that

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the Jeolla Province's provincial capital of Gwangju was facing acute water shortages that lead to rationing as it faced predictions it might run out of water completely, relying on water being trucked-in and having mobile desalination plants set up (in fact, South Korea has the first ever maritime mobile desalination plant. Restrictions meant that in this city of 1.4 million people running water was only available at home for two days a week, and that in some outlying villages taps were completely dry and water trucks were their only supply (Suk, 2023).

This drought not only has affected the lives of residents, but of food producers as well, obviously. This region in particular farms many abalones and one-third of the country's seaweed and 70% of its kelp via aquaculture, which do require freshwater and rain both during stages of their growth and the actual processing of them. South Korea is naturally susceptible to drought, often experiencing at least one a decade. Its previously most recent drought was from 2014-2015 (Suk, 2023).

South Korea already has some anti-drought and water protection measures, such as developing the first mobile marine desalination plant years before it was needed. This plant-ship was launched in 2018, and in the same year South Korea's Ministry of the Environment enacted the Framework Act on Water Management. This act mandated that local authorities introduce measures for sustainable access to clean water and reduce pollution, create policy frameworks to prevent and respond to water-based disasters such as floods, and began the policy of the central government creating a National Water Management Plan after a review every 10-years. The current plan adopted in 2020 brags that it is promoting innovation by focusing on water infrastructure networks to connect the nation's water resources better in the case of a localized

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issue, like the recent drought that is primarily affecting the south, by means such as creating more sophisticated pipe networks. Additionally, it has set goals such as protecting and preserving clean groundwater, restoring aquatic ecosystems in basins and rivers, diversifying water sources, better infrastructure and systemic responses to prevent and reacting to flooding and droughts, and using smart technology to manage water and predict future needs (*Presidential Water Commission, 2023)*.

The crises of the war in Ukraine and the COVID-19 pandemic have also shown some faults in the South Korean system. Disrupted global supply chains which South Korea relies on for much of its food led to a large increase in prices as goods became scarcer, such as a 47% price increase in grain imports between February 2020 and 2022 and a 30% rise in the price of flour, and this was prior to the war in Ukraine. From 2016-2020 South Korea was the eighth largest importer of Ukrainian grain and the third largest importer of Russian corn, and after the war prices only continued to increase and food retailers in South Korea saw some financial strain. The price of sunflower oil, of which Ukraine is the world's top producer, increased by 28.6% in Korea in just the first few months of the conflict (Bhadra, 2023; Kim, 2022; National Platform for Business Development, 2021).

The price of food has only continued to increase since the invasion of Ukraine in early 2022. South Korea in 2024 ranked third among the 38 country members of the Organization for Economic Cooperation and Development (OECD) in inflation at 5.3%, behind only Iceland at 7.5% and Turkey at 71%. Much of this 5.3% is because of the rise of food prices, had an inflation rate of nearly 7% as of February 2024, and has consistently stayed at over 5% since

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October 2023. Fruits in particular are affected, with the price in apples increasing by a huge 88% in a single month, the largest since inflation data started being kept in 1980 (Hae-Yeon, 2024).

Overall, South Korea's food self-sufficiency and food security has been degrading for decades, but at a low, relatively controlled rate that was made up for by the country's wealth and ability to import. It faces geographic challenges such as its mountain-dominated landscape but generally is spared from many other natural challenges such as frequent disasters or pollution, aside from the decadal drought. It seems that the government has become much more sensitive to the issue of food security in recent years and is taking measures to alleviate this, but other than managing things like droughts and improving rice farming efficiency, these methods will not be able to do things like consolidate small farms or bring meaningful amounts of young people to the agricultural sector. From 2009 to 2019 the amount of available farmland declined by a quarter because of losses to urbanization and industrialization, and this trend will likely continue, as will the aging of the farmers, with the average farmer and fisher being 66 years old in 2020. On top of this, food waste increased by 25% from 2000 to 2019. Dealing with these challenges would require systemic reform in governance, urban planning, and, in the case of aging farmers, society at large, meanwhile the government seems to be focusing on rice efficiency and drought mitigation, which will not alleviate these issues (Jeon et al., 2022; O'Shaughnessy et al., 2021).

6.3 Potential Future Challenges

South Korea has declining rates of self-sufficiency, especially in certain crops like wheat and beans. Its major issues are primarily demographic and geographic challenges brought on by

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its mountainous landscape and urbanization. It has plans to increase the number of younger workers in the agricultural sector and introduce greater resiliency and efficiency in the case of catastrophe. These measures are unlikely to reverse its declining self-sufficiency, but rather make it more adaptable in the event of challenges.

6.3.1 Environmental Degradation

South Korea has a relatively clean environment. It faced serious pollution for much of the 20th century because of its rapid industrialization. This was a major issue for the nation, but in 1995 South Korea enacted the Soil Environment Conservation Act which led to nation-wide soil testing and purification. According to nation-wide soil tests in 2018 only 50 locations had concerning levels of pollution, making up only 2% of samples with 98% being below the level of concern, and most of these places being in major metropolitan and industrial areas. Water pollution does exist but seems to be mild and on-par with other responsible, industrialized countries. Air pollution has become increasingly worse over the years because of industrialization, reliance on coal power plants, diesel vehicles, and winds blowing from the more-polluted China, which if left unchecked may continue to worsen and affect crop production (Lee, 2022; Mesmer, 2023).

South Korea's unique geography also creates an issue for it. Because of its mountainous landscapes, geological features, and most of the rainfall coming during one time of the year, soil erosion has been an age-old issue in the land. This not only affects farmers directly when it happens, but affects the whole landscape and can cause deforestation, which then contributes to

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greater droughts as humidity is not captured by the landscape. However, the nation has already adapted to this by various methods, and soil erosion has consistently declined since the government began combatting this in the 1980s (Woo, 1982; Jeon et al., 2022; Park et al., 2011).

In terms of climate change South Korea faces some unique conditions. Sea level rise will of course submerge existing arable land and low-lying regions, especially in the country's more rural south. Additionally, it will face more typhoons, with more arriving on the peninsula in recent years than in previous decades, as not only are more typhoons being formed, but their Pacific northern turning point had been going farther north, meaning that more of typhoons are more likely to make landfall in South Korea. Environmental issues in nearby countries have also affected South Korea; dust and sand swept up by the wind from Mongolia and the Gobi Desert sometimes reach South Korea, and soil erosion and desertification in Mongolia and China will likely increase this occurrence (Lee, 2022).

Somewhat paradoxically, South Korea is predicted to have more severe droughts and more overall rainfall. Their decadal droughts have been getting longer, but the country is expected to also experience longer wet seasons starting and ending later, but also with a secondary increase in rainfall during the Autumn months which is not historically typical. In total, South Korea's precipitation is expected to increase by 5-25% (Jung, Choi, 2022).

6.3.2 Regional Conflict

There are two major flashpoints that could cause a regional conflict around South Korea. The most obvious of which would be the Korean Peninsula itself, as South Korea shares a border

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with the boorish North Korea, which South Korea is still technically at war with. The outcome and the level of devastation in a war betwixt Koreas is almost impossible to truly estimate. During the Korean War of the 1950s North Korea was able to take over almost all of South Korea, until South Korea and allied forces took over almost all of North Korea, before the conflict stabilized along their current border around the De-Militarized Zone. This is unlikely to occur in the same way again; the more technologically advanced and populous South Korea would almost certainly win and not lose too much ground, unless weapons of mass destruction were deployed, and thus keep most of their farmland from the conflict, although a draft of military-aged men would certainly hamper any efforts to reduce the average age of farmers.

To Korea's south is the East China Sea and farther again the South China sea, both of which have contested territories between China, Taiwan, and Japan. China accounts for 15% of South Korea's food imports, and imports from the EU that make up another 10% pass through this area. In the case that China has some food rationing or other export restrictions on agriculture, South Korea would lose this 15%, and then the other 10% as shipments would be hampered by conflict en route. South Korea would likely increase imports from North America to compensate, which would come from its east and pass through a northern route via Japanese waters. Should this route also somehow be disrupted, South Korea would be in a rather dire situation. If both the Sea of Japan and China Seas were inaccessible for shipping, and with no friendly land neighbors, South Korea would effectively be cut off from the rest of the world commercially and would struggle to feed its population.

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6.3.3 International Disruption

As could be seen in the wake of the COVID-19 pandemic and the war in Ukraine, South Korea is vulnerable to international disruption. Previously South Korea was a major importer of Ukrainian and Russian corn and wheat, and obviously that is not quite the case anymore. China and the United States combined make up almost 40% of all South Korean food imports, and in the case of some sort of crises in either country would seriously affect South Korea food security. If there were some levels of severe political instability or environmental catastrophe in the United States and China simultaneously it would create a shock to South Korea's entire supply of things like wheat and dairy. South Korea could potentially shift its suppliers for these goods to South America or Australia and New Zealand, but it would likely not be enough to meet demand and would also have to rely on these regions not being affected by whatever international disruption would be going on at the time.

Furthermore, South Korea has an economy heavily based on exports of manufactured goods and should its export markets face disruption or be unreachable in some way, local living standards and incomes may fall dramatically and strain the country's ability to pay for its vast 6.3.3 food imports.

7. Conclusion

The research questions of this thesis have been: How is food secure are these countries? What are they doing to maintain food supplies for their population? And how might their food-supply strategies perform in the near future?

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Based on the analysis of these countries done, we can now answer these questions. For the first question, we can safely state that none of these countries are particularly food secure. They are food secure in the sense that they have the economic and logistic means to import food and they have not experienced food crises in recent times, but their systems are entirely reliant on this. The most quantifiable metric for this is their self-sufficiency rate: 37% for Japan, 44% for South Korea, 56% for Taiwan, and 66% for China, but this information alone does not answer this question. Their ability to import food means that in the recent past and in the present they are food secure as they are able to feed their population, but it a system and technique that hinges entirely on the globalized economy to provide this, and anything ranging from famine among their producers, to economic decline preventing them from being able to afford the imports, to any other crises could shatter this system, and this applies to all four of the countries.

For the second question, what are they doing to maintain food supplies, there are not only imports but also local production techniques. These are myriad and range between countries, but things that these countries have in common is prioritizing rice production as a staple crop, using smart technologies to improve logistics, and trying to encourage youth to become farmers. Generally, however, these countries are not willing and likely incapable to make themselves properly self-sufficient in the near future.

The final question, how will these systems hold up in the near future, varies by country. Three scenarios were considered: environmental degradation, regional conflict, and international disruption.

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In the case of Taiwan, environmental degradation brought on by climate change will severely affect domestic food production, as its fishing waters are bleached and its climate shifts to being less suitable to traditional crops. Regional conflict would also thoroughly devastate the island-nation more than anything, as it may entirely prevent the country from importing food that it relies on and could realistically result in famine. For international disruption it is also vulnerable, as its food supplies rely on a handful of friendly nations to be able and willing to supply them.

In China's case, environmental degradation is already at severe levels. It does have the highest self-sufficiency rate of these mentioned nations, but this is declining rapidly, and has only been able to boast this thanks to favorable geography and a vast labor pool, as well as low food standards. Yet, the water, air, and soil pollution also mean that arable land is declining and what food is produced contains toxins. For regional conflict it is probably the most resilient, with enough friendly or neutral nations to make up for any replacement of imports while its agricultural heartlands would remain safe and distant from a frontline. For international disruption it is also relatively resilient, with food stores and the geographic and political ability to diversify suppliers to weather the crisis.

Japan is threatened by climate change in flooding of arable land and soil erosion, as well as extreme weather events, but overall, it is the only one that seems like it could potentially have a net-benefit from climate change as it would be able to expand agriculture in its colder north. In regional conflict it is also resilient, with its agricultural lands being distant from any potential

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frontlines and the implausibility of a blockade. International disruption is its greatest threat, having the lowest self-sufficiency and the highest reliance on a globalized economy.

South Korea likewise has a relatively clean environment and is threatened by climate change primarily by flooding and soil erosion as well as both more rainfall and droughts but has plenty of potential and means to adapt. Regional conflict would be unpredictable depending on its nature, but would likely threaten its ability to import food, or possibly even produce it in the case of a conflict with its one neighbor, although if the conflict becomes larger it could potentially disrupt their entire ability to import and severely affect them. International disruption would affect them similarly to Japan and for the same reasons, but not as severely as it has a much more significant self-sufficiency rate.

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