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Gustavo F. Ferreira

Jamie A. Critelli

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Taiwan's Food Resiliency—or Not—in a Conflict with China

Gustavo F. Ferreira and Jamie A. Critelli

ABSTRACT: The US military, intelligence, and diplomatic communities have overlooked a key vulnerability in their assessment of a potential military conflict between China and Taiwan—Taiwan's growing reliance on agricultural imports and its food stocks (except for rice) that could endure trade disruptions for only six months. This article assesses Taiwan's agricultural sector and its ability to feed the country's population if food imports and production are disrupted; identifies the food products that should be prioritized in resupply operations, based on Taiwan's nutritional needs and domestic food production; and outlines the required logistical assets. These findings underscore the urgency for US military planners to develop long-term logistical solutions for this complex strategic issue.

Keywords: China, Taiwan, food insecurity, resiliency, naval blockade

Recent increases in global food prices following the COVID-19 pandemic, crop failures in key producing countries, and the war in Ukraine have reminded many countries about the risks associated with dependency on food imports to feed their populations. As Taiwan industrialized its economy and developed key manufacturing sectors (such as the semiconductor sector), it also allowed structural risks to grow within its food supply system. Due to limited arable land and rapid urbanization, Taiwan's agricultural sector has remained relatively small. Consequently, the country's ability to feed itself has decreased over the years, and in 2018, it ranked as the 16th-largest agricultural importer, with food imports covering over two-thirds of its annual caloric intake.[1]

This import dependency varies across products and is remarkably high for feed grains and oilseeds (such as wheat, soybeans, or corn), commodities primarily consumed by Taiwan's food-processing and livestock

1. "Taiwan – Country Commercial Guide: Agricultural Sectors," International Trade Administration/U.S. Department of Commerce (website), September 16, 2022, https://www.trade.gov/country-commercial-guides/taiwan-agricultural-sectors; Alex Beckman, "Opportunities for U.S. Agricultural Exports in Taiwan – International Agricultural Trade Report, Foreign Agricultural Service/U.S. Department of Agriculture (website), April 8, 2019, https://www.fas.usda.gov/data/opportunities-us-agricultural-exports-taiwan; and Troy Lai and Lucas Blaustein, "Taiwan: Taiwan Confident in Food Stocks as COVID-19 Disrupts International Trade," *Attaché Report* (GAIN), Foreign Agricultural Service/U.S. Department of Agriculture (website), April 14, 2020, https://www.fas.usda.gov/data/taiwan-taiwan-confident-food-stocks-covid-19-disrupts-international-trade.

sectors. The United States is the leading supplier of food and agricultural products to Taiwan because of a historically strong trade relationship. Australia, China, Japan, New Zealand, and Thailand are also important food suppliers.[2] In this context, Taiwan's food system has become extremely vulnerable to external threats, including a direct military escalation with China or a prolonged Chinese naval blockade in the Taiwan Strait.[3] Disruptions to this shipping route could bring Taiwan's vital food imports to a halt and force its people to change their diets dramatically by replacing higher-value food products (for example, meats or processed foods) with traditional staples, such as rice or sweet potatoes.

As a response, Taiwanese authorities have made food security central to the country's agricultural policy, with improvements in overall food security based on four levers: increasing domestic food production, increasing food inventories, increasing food supply-chain resiliency, and reducing reliance on imports. This policy faces important challenges, including a lack of competitiveness in international markets, an aging farming population, and the scarcity of arable land. Furthermore, boosting domestic food production depends on imported fertilizers, fuel, and other chemical inputs.[4]

Pundits increasingly highlight the importance of Taiwan modernizing its armed forces, forging alliances, and preparing to endure—or even break—a possible Chinese blockade by stockpiling fuel or planning for airlifts.[5] To our knowledge, however, Taiwanese leadership has not focused on one of the country's major vulnerabilities—a great dependence on imported food products. This study therefore fills the literature gap by (1) assessing the resilience of Taiwan's agriculture and its ability to feed the population in the context of a military conflict with China, (2) identifying the key food products that should be prioritized in resupply operations or early

2. Beckman, "U.S. Agricultural Imports in Taiwan."
3. Béatrice Knerr, "Food Security vs. WTO Membership in Taiwan," in *Proceedings of the 3rd Annual Conference of the European Association of Taiwan Studies* (*EATS*) (Paris: EATS, March 2006).
4. Effendi Andoko et al., "Review of Taiwan's Food Security Strategy," Food and Fertilizer Technology Center for the Asian and Pacific Region (FFTC-AP) (website), September 10, 2020, https://ap.fftc.org.tw/article/2570.
5. "How to Avoid War over Taiwan: A Superpower Conflict Would Shake the World," *Economist* (website), March 9, 2023, https://www.economist.com/leaders/2023/03/09/how-to-avoid-war-over-taiwan.

stock buildup efforts, and (3) exploring three different scenarios and possible solutions to strengthen Taiwan's food resiliency.

Agricultural and Food Self-Sufficiency Overview

Taiwan's agricultural sector has lost economic weight over the years. In 2019, it accounted for less than 2 percent of the country's gross domestic product (GDP) in comparison to 30 percent during the 1960s. It also employed only 4 percent of the total Taiwanese workforce. Such trends are normally observed in industrialized nations where economic policies increasingly focus on industrial development and services. Nevertheless, agricultural output typically continues to climb in these countries as fewer but larger farms become more productive. In Taiwan, however, for various reasons, the nation has gone from a surplus in agricultural trade during the 1980s to a heavy reliance on imports for most major food staples today.

The low availability of arable land has limited agriculture and food production across Taiwan. Agricultural production in 2018 used 520,000 hectares (nearly 1.3 million acres), falling short of the national target prescribed by Taiwan's Ministry of Interior of 740,000 to 810,000 hectares (1.8 to 2 million acres). Additionally, other lucrative economic activities (such as industrial production or urban development) often compete for the same limited available land. After all, Taiwan is approximately the size of Delaware and Maryland combined.[6] Furthermore, Taiwan's small-scale farming model hinders the agricultural sector's ability to compete in domestic and international markets. Contrary to what has happened in other industrialized nations, the average farm size in Taiwan has steadily dropped for decades. Farmers operating very small farms cannot achieve economies of scale, adopt new technologies, or employ certain large or expensive farm implements.[7]

As domestic food production declined, Taiwan's general food self-sufficiency rate fell to 32 percent during the 2010–12 world food price crisis. Prices for imported commodities (such as grains) increased dramatically, and the domestic food processing and livestock sectors

6. "Field Listing: Area - Comparative," in *The World Factbook* (Washington, DC: Central Intelligence Agency, 2021), https://www.cia.gov/the-world-factbook/field/area-comparative/.
7. Andoko et al., "Taiwan's Food Security Strategy"; and Knerr, "Food Security."

struggled to stay in business. Taiwan narrowly escaped the crisis by depleting its national three-month grain stockpile.[8]

Following the crisis and recognizing the strategic importance of improving food self-sufficiency, the Taiwanese government took steps to increase domestic food production by revitalizing fallow land through subsidies, incentivizing farmers to plant grains, and encouraging the population to consume more rice, which is abundant in Taiwan.[9] Despite these efforts, Taiwan failed to improve the situation significantly, as the food self-sufficiency rate ranged between 31 and 35 percent during the 2009–18 period and hit 40 percent in 2020.[10]

The growing imbalance of food self-sufficiency levels across commodities adds another layer of complexity. For example, rice continues to be Taiwan's major crop in terms of land and labor—nearly half of all Taiwanese farmers grow rice. Years of policies involving public purchases, however, have led to rice overproduction and an increasing dependency on imports of other key commodities, such as wheat, corn, and soybeans.[11] A lack of storage management (for example, proper refrigeration or adequate packaging) and the discard of low-quality or damaged food have also undermined food self-sufficiency, resulting in high rates of food loss throughout the supply chain. For example, 40 percent of vegetables and fruits went to waste during 2018.[12]

As figure 1 shows, China's and Taiwan's planting and harvesting seasons vary across crops. A war during those seasons would greatly disrupt agricultural production in Taiwan, and favorable conditions for an amphibious attack (March–May and September–October) overlap with these seasons (April–May for planting and August–September for harvesting).[13] Furthermore, crop stock levels in Taiwan will be at their lowest levels during the weeks preceding the harvest window, as inventories are gradually consumed between harvest periods. Thus, grain stock levels in Taiwan will likely be at their lowest levels during the months

8. Ching-Hsien Ho et al., "The Impact on Food Security and Future Adaptation under Climate Variation: A Case Study of Taiwan's Agriculture and Fisheries," *Mitigation and Adaptation Strategies for Global Change* 23, no. 3 (March 2018): 311–47, https://doi.org/10.1007/s11027-017-9742-3.
9. Lee Wu-chung, "Promoting Self-Sufficiency in Food," *Taipei Times* (website), March 4, 2011, https://www.taipeitimes.com/News/editorials/archives/2011/03/04/2003497297; and "2014 Council of Agriculture (COA) Annual Report," COA/Executive Yuan, Republic of China (website), March 2015, https://eng.coa.gov.tw/ws.php?id=2504046.
10. Andoko et al., "Taiwan's Food Security Strategy."
11. Ching-Hsien Ho et al., "Impact on Food Security"; and Knerr, "Food Security."
12. Andoko et al., "Taiwan's Food Security Strategy."
13. "America and China Are Preparing for a War over Taiwan," *Economist* (website), March 9, 2023, https://www.economist.com/briefing/2023/03/09/america-and-china-are-preparing-for-a-war-over-taiwan.

of July and August, the latter of which also overlaps with the ideal time for an amphibious attack.

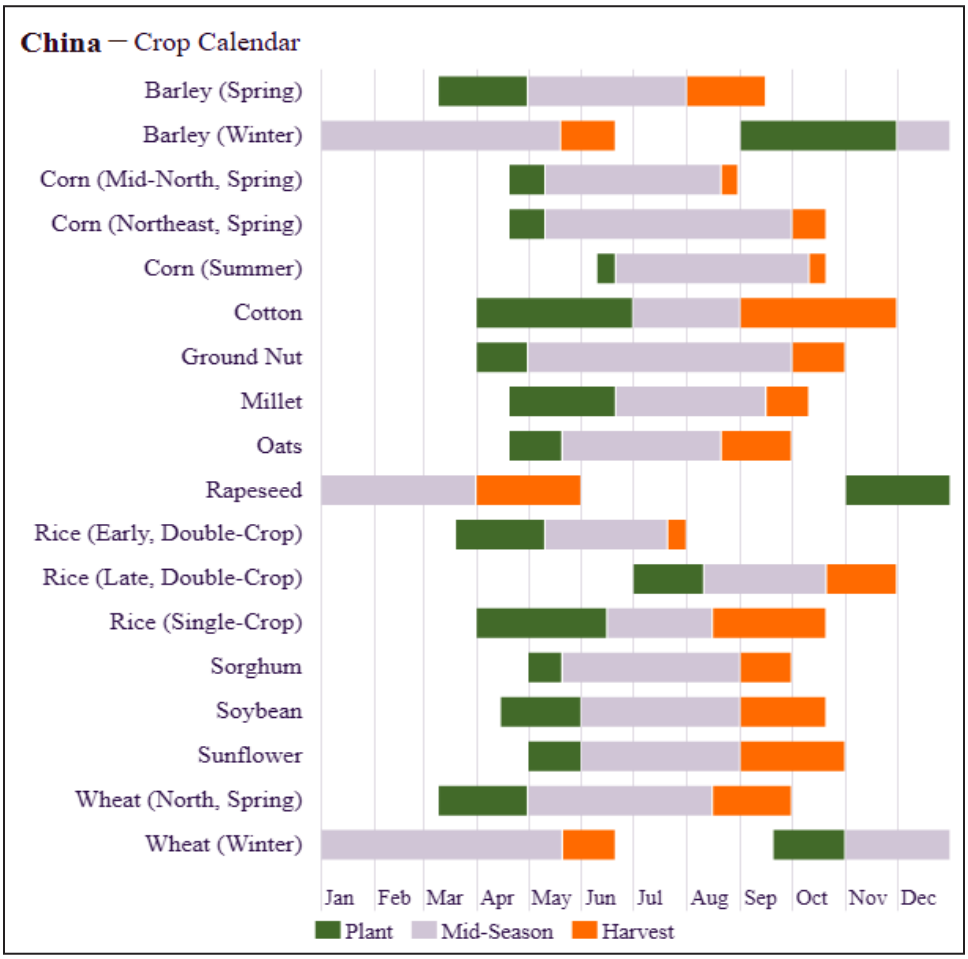

Figure 1. Crop calendar for China and Taiwan
(Source: "Crop Calendars for China and Eastern Asia," Foreign Agricultural Service/U.S. Department of Agriculture (website), n.d., https://ipad.fas.usda.gov/rssiws/al/crop_calendar/che.aspx)

Commodity	Domestic Production	International Trade		Change in Stocks	Domestic Supply	Disposal of Domestic Supply						
		Import	Export			Feed	Seed	Manufacture	Waste	Food (Gross)	Extraction Rate (%)	Food (Net)
Cereals	**1,387**	**6,264**	**377**	**-227**	**7,335**	**4,520**	**14**	**189**	**44**	**2,568**	**82**	**2,095**
Rice	1,242	128	228	-242	1,218	4	14	39	13	1,148	88	1,010
Wheat	1	1,401	85	-48	1,365	36	0	67	25	1,237	74	909
Corn	143	4,419	1	64	4,497	4,298	0	24	5	170	-	170
Sorghum	1	65	-	-	65	40	0	26	-	-	85	-
Other	1	251	63	-	190	142	0	33	0	14	50	7
Starchy Roots	**291**	**1,560**	**218**	**84**	**1,563**	**11**	**3**	**0**	**104**	**1,445**	**47**	**683**
Sweet Potatoes	214	1	1	-	214	11	0	-	18	185	-	185
Cassava	1	1,214	179	58	978	0	-	0	49	929	18	167
Potatoes	62	337	2	27	371	-	2	-	37	331	-	331
Other	14	7	36	-	-	-	-	-	-	-	25	-
Sugars and Honey												
Sugars	56	634	73	-	-	-	-	2	-	583	-	583
Honey	13	4	5	-	13	-	-	-	-	13	-	13
Pulses and Oilseeds	**69**	**2,770**	**16**	**-32**	**2,855**	**315**	**5**	**2,027**	**25**	**483**	**98**	**475**
Soybeans	4	2,591	9	-32	2,618	315	2	1,967	19	314	-	314
Peanuts	50	13	1	-	62	-	4	24	1	34	75	26
Sesame	2	43	0	-	45	-	0	36	0	9	-	9
Other	13	123	6	-	130	-	0	0	4	126	-	126
Vegetables	**2,384**	**483**	**77**	**-**	**2,790**	**-**	**5**	**-**	**278**	**2,506**	**-**	**2,506**
Green Leafy	980	119	9	-	1,090	-	-	-	109	981	-	981
Roots	187	47	10	-	224	-	-	-	22	202	-	202
Bulbs and Tubers	585	111	8	-	688	-	5	-	68	615	-	615
Flowers and Fruits	589	184	49	-	724	-	-	-	72	652	-	652
Mushrooms	42	23	2	-	63	-	-	-	6	57	-	57
Fruits	**2,627**	**594**	**192**	**-**	**3,028**	**-**	**-**	**1**	**303**	**2,725**	**-**	**2,725**
Bananas	337	0	3	-	334	-	-	-	33	301	-	301
Pineapples	403	21	31	-	393	-	-	-	39	353	-	353
Citrus	466	81	33	-	513	-	-	-	51	462	-	462
Melons	207	1	1	-	207	-	-	-	21	187	-	187
Other	1,214	491	124	-	1,581	-	-	1	158	1,422	-	1,422

Table 1a. Taiwan's food balance
(Source: Taiwan Council of Agriculture)

Commodity	Domestic Production	International Trade		Change in Stocks	Domestic Supply	Disposal of Domestic Supply						
		Import	Export			Feed	Seed	Manufacture	Waste	Food (Gross)	Extraction Rate (%)	Food (Net)
Meats	**1,645**	**473**	**8**	**12**	**2,099**	**-**	**-**	**82**	**42**	**1,974**	**-**	**1,974**
Pork	855	94	5	12	932	-	-	82	19	831	-	831
Beef	8	158	1	-	165	-	-	-	3	162	-	162
Sheep and Goat	2	22	0	-	23	-	-	-	0	23	-	23
Poultry	780	197	1	-	976	-	-	-	20	957	-	957
Other	-	2	-	-	2	-	-	-	0	2	-	2
Eggs	**488**	**3**	**3**	**-**	**488**	**-**	**-**	**-**	**10**	**478**	**-**	**478**
Fish and Seafood	**984**	**459**	**746**	**-**	**697**	**-**	**-**	**19**	**34**	**644**	**-**	**644**
Fish	722	250	632	-	341	-	-	11	16	313	-	313
Shrimp and Crab	21	74	4	-	92	-	-	5	4	83	-	83
Cephalopoda	152	47	104	-	95	-	-	1	5	90	-	90
Shellfish	76	68	4	-	140	-	-	-	7	133	-	133
Other	3	11	1	-	12	-	-	2	1	10	-	10
Dried (salted)	9	9	1	-	17	-	-	-	1	16	-	16
Milk	**461**	**240**	**8**	**0**	**694**	**-**	**-**	**-**	**5**	**688**	**-**	**688**
Fresh	461	53	0	-	514	-	-	-	5	509	-	509
Powdered	-	73	5	0	67	-	-	-	-	67	-	67
Other	-	115	3	-	112	-	-	-	-	112	-	112
Oils and Fats	**395**	**392**	**39**	**2**	**746**	**23**	**-**	**182**	**2**	**539**	**-**	**539**
Vegetable	**358**	**315**	**33**	**2**	**637**	**-**	**-**	**175**	**1**	**461**	**-**	**461**
Soybean	334	0	25	2	307	-	-	-	1	306	-	306
Peanut	7	0	0	-	6	-	-	-	0	6	-	6
Sesame	14	3	5	-	13	-	-	-	0	13	-	13
Other	3	311	3	-	311	-	-	175	0	136	-	136
Animal	**37**	**77**	**6**	**-**	**109**	**23**	**-**	**7**	**0**	**78**	**-**	**78**
Lard	37	3	0	-	40	11	-	7	0	22	-	22
Butter	-	28	0	-	28	-	-	-	0	28	-	28
Other	-	46	6	-	41	12	-	-	0	29	-	29

Table 1b. Taiwan's food balance
(Source: Taiwan Council of Agriculture)

Resupplying Taiwan with Food Products in a Conflict

This section assesses Taiwan's and its allies' ability to feed the island's population in the event of a military conflict with China, addresses three different research questions, and explores three possible scenarios.

Question 1: Given Taiwan's dependency on imported food, how resilient would its agricultural sector be in the context of a military attack and trade embargo by China?

Taiwan has been able to feed its population consistently through a combination of domestic food production and food imports. In 2019, daily per capita food supply in Taiwan averaged 2,958 kilocalories, which was sufficient to meet the country's minimum daily caloric per capita requirement of 1,896 kilocalories.[14] Without imports, however, Taiwan could not maintain that positive nutritional balance for long (see tables 1a and 1b).

Hence, the buildup of public food stocks has been a key component of Taiwan's food resiliency strategy. For example, during the COVID-19 crisis, Taiwanese authorities assured the populace the nation had enough food and agricultural commodity stocks to mitigate disruptions in agricultural trade for up to six months.[15] Taiwanese authorities have put a special focus on sustaining high levels of rice stocks through public purchases because the Taiwanese population consumes, on average, nearly 100,000 metric tons of rice per month.[16] Seasonal and annual rice stock levels vary; the early rice crop harvest normally begins in late July, while a second crop is harvested in October–November.

In April 2020, the US Department of Agriculture published a report indicating most of Taiwan's food stock levels would be sufficient to feed its population for up to six months, with one notable exception: with public stocks of 900,000 metric tons, rice is the only food product with reserves large enough to endure beyond six months.[17] It is important to note other sources present different levels of rice stocks lasting for longer periods of time.[18]

14. Max Roser, Hannah Ritchie, and Pablo Rosado, "Food Supply," Our World in Data (website), https://ourworldindata.org/food-supply.
15. Lai and Blaustein, "Taiwan."
16. "Production, Supply, and Distribution," Foreign Agricultural Service/U.S. Department of Agriculture (website), n.d., https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery.
17. Lai and Blaustein, "Taiwan."
18. John Van Trieste, "Tsai Hopes to See Taiwan Achieve 40% Self-Sufficiency in Food," Radio Taiwan International (website), April 17, 2020, https://en.rti.org.tw/news/view/id/2003097.

Nevertheless, if China imposes a naval blockade, rice stocks would likely be depleted at a faster rate than currently projected, as a dearth of imports of other food products would force higher consumption of domestically produced rice and other staple crops. The current analysis assumes Taiwan would have enough food to feed its population during a naval blockade for six months. This important timeline should guide US military planners and other US government agencies when developing strategies to supply Taiwan with the food products necessary to remain in the fight.

Question 2: In the event of a naval blockade enforced by China, which food products should be prioritized in early stock buildup efforts or resupply operations based on Taiwan's nutritional needs and domestic food production?

Following Chinese military aggression, commercial trade in and out of Taiwan will be disrupted. In this contested environment, Taiwan's policymakers and military planners will need to prioritize certain products when they build up food reserves or engage in resupply operations. As shown in tables 1a and 1b, Taiwan's food production in 2021 totaled 21,436,000 metric tons in the following categories: fruits (12.3 percent), vegetables (11.1 percent), meat (7.7 percent), cereals (6.5 percent), fish and seafood (4.6 percent), milk (2.2 percent), eggs (2.3 percent), oils and fats (1.8 percent), starchy roots (1.4 percent), sugar and honey (0.3 percent), and pulses and oil seeds (0.3 percent). For many categories, Taiwan's food production does not meet domestic demand, with imports covering the shortfalls. Changing consumption patterns and diet preferences have driven much of this dependency. For instance, rice consumption in Taiwan decreased over the years, while consumption of imported wheat steadily increased.

Next, assuming a partial or complete disruption of commercial trade in and out of Taiwan, it is important to identify food products that should be prioritized in any efforts to build up stockages before a conflict or that should be included in US and allied resupply operations. These food products break down into broader categories based on two factors: (1) wide consumption of the food product by the Taiwanese population, and (2) a large volume of Taiwan imports due to the inability of domestic production to meet national demand.

Grains and Oil Seeds

In most societies, crop products are the primary source of food and calories, and Taiwan is no exception.[19] Grains and grain products (such as rice and flours) provide the main source of calories and cover 52 percent of Taiwan's daily required carbohydrates. The country became heavily dependent on imported grains and oilseeds, however, which now account for about 60 percent of its agricultural imports volume.[20] More specifically, wheat, corn, and soybeans account for the largest agricultural import volumes, as imports almost fully meet Taiwan's domestic needs for these commodities that totaled 8.4 million metric tons in 2021 (see tables 1a and 1b).

For decades, Taiwan's wheat consumption has increased, driven by a thriving baking sector that produces popular goods such as wheat noodles and buns. With negligible wheat crops, Taiwan relies almost exclusively on imported wheat for the production of wheat flour.[21] Almost all imported corn and soybeans are used as feed for Taiwan's livestock operations—mostly poultry and hog. Because of the large consumption volumes and near-complete dependence on imports, Taiwan and its allies should prioritize this food category in any planning considerations to increase the island's food resiliency.

Animal Protein

Meat and aquaculture/fish products are two main sources of animal protein, whereas oilseeds and hulled seeds cover Taiwan's consumption of vegetable protein. Protein sources have evolved over the years as a new diet aligned with other industrialized societies gradually replaced the traditional diet. In 1961, plant-based protein accounted for 74 percent of Taiwan's total daily protein supply, with animal-origin protein for the remaining 26 percent. Fast-forwarding to 2017, animal-origin protein accounted for nearly half the country's protein supply.[22] Furthermore, households in Taiwan now spend more money on meat products (mostly chicken and pork) than any other food category. As shown in tables 1a and 1b, domestic production meets larger shares of domestic consumption

19. *Organisation for Economic Cooperation and Development* (*OECD)/UN Food and Agriculture Organisation (FAO) Agricultural Outlook 2014* (New York: OECD/FAO Publishing, 2014), https://www.oecd-ilibrary.org/agriculture-and-food/oecd-fao-agricultural-outlook-2014_agr_outlook-2014-en.
20. Ching-Hsien Ho et al., "Impact on Food Security."
21. Troy Lai and Oscar Lin, "Taiwan: Grain and Feed Annual," *Attaché Report* (GAIN) TW2022-0018, Foreign Agricultural Service/U.S. Department of Agriculture (website), April 13, 2022, https://www.fas.usda.gov/data/taiwan-grain-and-feed-annual-7.
22. Roser, Ritchie, and Rosado, "Food Supply."

of chicken and pork. Taiwan's beef production remains negligible, and imports sustain most beef consumption, with the United States being the top supplier.

With an annual consumption per capita of 39 kilograms (86 pounds), fish products account for a significant share (36 percent) of total animal-protein consumption. Taiwan's annual fish production averages 820,000 metric tons. Coastal and offshore fishing combined with aquaculture account for about 57 percent of Taiwan's demand for fishery products. Deep-sea fishing supplies over 5 percent of domestic demand while imports account for the remaining 37 percent. Despite being a crucial source of animal protein for the Taiwanese population, fish products are under threat. First, years of industrial pollution and overfishing have resulted in increased imports of fish and seafood products since 2006.[23] A Chinese naval blockade could certainly disrupt Taiwan's coastal and offshore fishing activities, deny the importation of fish products, and prevent Taiwanese aquaculture farm operations from securing grain-based meals.

Countering this threat comes with specific challenges. First, any buildup of national stocks of fish products would require large, costly refrigerated warehousing capabilities. Similarly, any US and allied attempts to deliver shipments of frozen fish products would require vessels with refrigerated containers. A logistically less complex alternative would be to prioritize the buildup of stocks of grain-based meals to sustain Taiwan's aquaculture farm operations.

Without some early actions, Taiwan could not maintain its current levels of animal protein consumption under a prolonged Chinese naval blockade. China would deny meat, seafood, and fish imports, and Taiwan's livestock and aquaculture sectors would run out of feed grains. This possibility represents the most serious threat to Taiwan's food security and underpins the importance of grain and oilseeds reserves and resupply options. Even if Taiwan decides to expand its grain and oilseeds stock storage capacity, large grain silos are expensive to build and would be vulnerable to Chinese attacks.

Chemical Inputs

An external disruption to Taiwan's food imports would force the country to return to a spartan 1940s-era diet of rice and sweet potatoes. This switch by itself would not be enough unless Taiwan manages

23. Ching-Hsien Ho et al., "Impact on Food Security."

to increase domestic agricultural production quickly. Such a boost in food production can only be achieved via higher yields or expanded cultivation. The scarcity of arable land limits the latter option. As to the former option, the war in Ukraine has shown how the disruption in the fertilizer trade caused a worldwide shortage and struggle to secure these key chemical inputs. Taiwan imported large volumes of chemical fertilizer in the 1950s until a domestic fertilizer industry emerged with the support of public policies and subsidies. Despite making progress, Taiwan continues to import chemical fertilizers and compounds (mostly urea and potassium chloride) from various countries, including China.[24]

In 2015, the annual volume of chemical fertilizers used was approximately 1.01 million metric tons, including ammonium sulfate and potassium chloride.[25] If Taiwan cannot secure a high enough volume of fertilizers, pesticides, and herbicides, local farmers will struggle to maintain yields and productivity. Therefore, Taiwan must build up sufficient stocks of chemical inputs to sustain and expand domestic food production during a Chinese naval blockade. Taiwanese authorities must manage these stocks and prioritize distribution to specific food producers based on strategic and nutritional considerations (for example, grain farmers get priority access to chemical inputs, unlike vegetable growers). Instead of waiting, Taiwan and its allies should prioritize the delivery of these inputs early in—or even before—the outbreak of conflict.

Other Food Products

Consumption of other important products common in the modern Taiwanese diet (such as apples, sugars, potatoes, or butter) completely or heavily relies upon imports.[26] For some of these products, much lower production costs in mainland China take away economic incentives to expand domestic production in Taiwan.[27] Finally, Taiwan consumes large volumes of mostly imported cassava. By volume, cassava imports in 2021 were only surpassed by imports of corn, soybeans, and wheat (see tables 1a and 1b). Cassava has an extremely limited shelf life

24. "Economic Milestones," *Taiwan Today* (website), October 1, 1967, https://taiwantoday.tw/print.php?unit=8,8,29,32,32,45&post=13840.
25. I Han and Min-Hsien Yang, "Subsidy Policy Evolution to Chemical Fertilizers and Management Information System Processing in Taiwan," FFTC-AP (website), March 6, 2015, https://ap.fftc.org.tw/article/869.
26. Andoko et al., "Taiwan's Food Security Strategy."
27. Knerr, "Food Security."

(24–72 hours after harvest), making it impossible for Taiwan to build up strategic reserves of this starchy root.[28]

Question 3: Under three different scenarios, what logistical assets would Taiwan need to strengthen its food resiliency?

Three scenarios show the different levels of threats to Taiwan's food security. They include a partial or a complete naval blockade imposed by China and discussions about Taiwan and its allies' capabilities to support large-scale, fast-paced logistical operations that bring key agricultural products to the island. These scenarios are not exhaustive and are based on the realities on the ground and in the literature on this issue.

Scenario 1: China effectively denies US and allied food resupply operations.

Through shared land borders, the United States and other NATO members have supplied Ukraine with massive amounts of military equipment, ammunition, and other supplies. With Taiwan's island geography, a similar supply effort during a Chinese naval blockade may not be possible because the People's Liberation Army (PLA) Navy is now the world's largest navy, with 355 combat-capable vessels that can cover a large area. The PLA Rocket Force could also deny freedom of movement of any adversary's naval forces with its anti-ship ballistic missiles. In fact, the PLA Rocket Force's doctrine focuses on three objectives: (1) targeted destruction of major capital ships, (2) general aerial defense, and (3) the imposition of focused naval blockades.[29]

A report published by the Center of Strategic and International Studies think tank argues that once war starts, Chinese naval and air assets would make it extremely difficult and risky for cargo ships and airlifts to reach Taiwan. Moreover, China would attempt to capture major operational ports to use civilian merchant ships to supply its invasion of Taiwan and ease demands on its amphibious fleet.[30] The Taiwanese

28. Rockefeller Foundation, *Cassava Innovation Challenge: Overview of Cassava Value Chain and Drivers of Spoilage*," https://www.rockefellerfoundation.org/wp-content/uploads/The-Rockefeller-Foundation-Cassava-Innovation-Challenge-Overview-of-Cassava-Value-Chain.pdf.
29. Benjamin E. Mainardi, "The People's Republic of China at Sea: A Sea Power Ascendant?" *Strife Journal* 17 (Winter 2022): 63–89.
30. Mark F. Cancian, Matthew Cancian, and Eric Heginbotham, *The First Battle of the New War: Wargaming a Chinese Invasion of Taiwan* (Washington, DC: Center for Strategic & International Studies, January 2023), https://www.csis.org/analysis/first-battle-next-war-wargaming-chinese-invasion-taiwan.

military would likely respond by blocking all these major ports and beaches with various obstacles, such as sea mines or sunken ships.[31] With all the major ports inoperable, the United States and its allies could no longer use them to unload critical food supplies. If cut off from external assistance, Taiwan would need sufficient food supplies before a conflict with China starts, which various actions and policies could achieve—with significant challenges.

Increasing Food Reserve Levels

As discussed, except for rice, Taiwan's food stockpiles would last approximately six months. While such stock levels may sustain Taiwan in a rapidly evolving kinetic conflict with China, they could fall short during a prolonged naval blockade. Improving Taiwan's food supply system resilience will require major investments in storage capacity. These investments could yield important returns beyond readiness for a military conflict and prepare Taiwan for other shocks, such as natural disasters, pandemics, or global food price spikes.

Recognizing the importance of establishing self-sufficiency in critical strategic industries, the Taiwanese government is fomenting strategic stockpiles of key materials, such as basic foodstuffs, medical supplies, crude oil, construction products, high-tech batteries, and resources and equipment used by the semiconductor industry. These efforts include a US$295 million investment to improve Taiwan's cold-chain infrastructure and enhance the country's ability to stockpile essential food products and handle temporary food shortages and price volatility.[32] These large storage facilities (grain silos or cold storage warehouses) are also vulnerable targets for the PLA Navy, Rocket Force, and Air Force. Thus, with US military and allied assistance, Taiwan's military must develop protective systems to defend this critical infrastructure from kinetic and cyber attacks.

Increasing Domestic Food Production

Taiwan can also become more resilient by increasing domestic food production. This effort will take time and require significant changes to the country's agricultural structure characterized by small farms and an aging farming population. Furthermore, limited farmland and agricultural labor will cap the expansion of traditional agricultural

31. "America and China."
32. Oscar Chung, "Kept in Reserve," *Taiwan Today* (website), May 1, 2021, https://taiwantoday.tw/news.php?unit=8&post=200663&unitname=&postname=Kept-in-Reserve.

production. To circumvent these constraints, Taiwanese authorities should consider developing a victory garden program like those of the United States during World Wars I and II that could be activated during a military conflict and strengthen its food resilience against Chinese aggression. By the end of 1944, Americans established 20 million victory gardens that offset 40 to 60 percent of the annual fruit and vegetable production in the United States. The beneficial gardens utilized limited water and gray water in a crisis and recaptured nutrients typically discarded in a traditional sewage network.[33] With US and allied assistance, Taiwan could establish a nationwide victory garden program. The United States and its allies could provide training and extension services and the essential inputs (for example, gardening tools, seeds, or fertilizers) for the victory gardens.

Another approach would be the promotion of "closet gardens." In densely populated Taiwan, hydroponics would allow most households to produce leafy vegetables within the home.[34] Hydroponic vegetable production has a steep learning curve, however, and requires considerable up-front investment. Preferred hydroponic variants include Dutch bucket and Kratky culture systems due to their resilience against interrupted power sources.

Dutch bucket systems consist of three- to five-gallon pails filled with a slightly porous growth medium, growing a single vegetable. This method is commonly used for solanaceous (nightshade family) or brassicaceous (cabbage family) crops. These systems are watered one to four times daily with a defined nutrient solution.[35] Any effluent drains into a central holding tank and recirculates during the next watering.

Kratky culture consists of growing vegetables into mature vegetable size-appropriate containers that include 100 percent of the water and fertilizer the plant will need to reach maturity. These containers are always impervious to light. As roots grow into the water solution, the upper roots become aerial in nature, and the plant does not require

33. Laura Schumm, "America's Patriotic Victory Gardens," History Channel (website), August 31, 2014, last updated September 1, 2018, https://www.history.com/news/americas-patriotic-victory-gardens; and "Rosie the Riveter WWII Home Front: History and Culture," National Park Service (website), last updated October 27, 2022, https://www.nps.gov/rori/learn/historyculture/index.htm.
34. Rob Girling, "Home Hydroponics: Tech Trend or the New Victory Garden?" *Forbes* (website), June 30, 2020, https://www.forbes.com/sites/robgirling/2020/06/30/home-hydroponics-tech-trend-or-the-new-victory-garden/?sh=25b22d70545f.
35. Nisha Sharma et al., "Hydroponics as an Advanced Technique for Vegetable Production: An Overview," *Journal of Soil and Water Conservation* 17, no. 4 (January 2019): 364–71, https://www.researchgate.net/publication/330080392_Hydroponics_as_an_advanced_technique_for_vegetable_production_An_overview.

action oxygenation.[36] Dutch bucket and Kratky systems still require ideal light conditions for growth, but they do not need a system for nutrient solution oxygenation.

For these reasons, a specific hydroponic method to avoid is the nutrient film technique (NFT) since plants grown in this manner would expire within 30 minutes of the system losing electrical power. Pond culture and deepwater culture could also be utilized at scale if there is a backup means of oxygenating and recirculating the nutrient solutions. The ultimate goals of these programs should be to disperse the production of vegetables to the lowest level possible while using the most-resilient growing methods possible and reallocating as much vegetable-producing farmland as possible to grow grains.

With proper government and industry support, Taiwan could boost its production of vegetables and starchy roots. Moreover, such supply sources would be resilient to Chinese attacks because they comprise many small-size operations dispersed throughout the country. These initiatives would only increase domestic production in food categories where Taiwan already has high self-sufficiency rates (for example, vegetables) and would not address the country's dependency on certain food imports.

Scenario 2: The United States and its allies anticipate they can sustain limited resupply operations to Taiwan in the context of a Chinese naval embargo.

In line with the Black Sea Grain Initiative, which has kept critical grain corridors in Ukraine open to international buyers, China could allow limited maritime traffic to bring essential food products to Taiwan to avoid a major humanitarian crisis. For these food resupply operations to occur, China would have to allow maritime traffic across the Bashi Channel and the Sibutu Passage.

It is unclear, however, whether commercial shipping companies would be willing to operate in that region due to elevated risk and higher operational costs (for instance, exorbitant insurance rates and difficulties obtaining shipping letters of credit). In that case, US and allied navies may need to ensure the arrival of critical food supplies to Taiwan. This possibility raises the question of whether the US military and its

36. B. A. Kratky, "Three Non-Circulating Hydroponic Methods for Growing Lettuce," in *International Symposium on Soilless Culture and Hydroponics*, ed. A. Rodriquez-Delfin and P. F. Martinez, *Acta Horticulturae* 843 (2009): 65–72, https://www.ctahr.hawaii.edu/hawaii/downloads/three_non-circulating_hydroponic_methods_for_growing_lettuce.pdf.

allies could replace commercial operators and rally a significant number of cargo vessels capable of carrying large quantities of bulk commodities. These replacements would include different classes of vessels to ship bulk cargo and containers, ranging from Handysize (15,000–35,000 metric tons deadweight) to Capesize (above 150,000 metric tons deadweight).[37]

Trade data reveals the logistical complexity and sheer size associated with supplying enough food to feed Taiwan's population for a long period of time. To illustrate, it would require 47 Panamax-sized vessels—the largest ship that can cross the locks of the Panama Canal—to bring in the volume of soybeans imported by Taiwan in 2021 (2.6 million metric tons). Furthermore, a Lockheed C-5 Galaxy aircraft, the US Air Force's largest and only strategic airlifter, has a maximum payload of 122 metric tons. Such large food import volumes rule out the possibility of a Berlin airlift–type operation, especially if China contests the airspace surrounding Taiwan.[38]

Most agricultural imports arrive in Taiwan through four ports with the logistical infrastructure needed to handle and store the products, such as port cranes for containers, grain silos, and cold storage for fresh fruits and vegetables (see figure 2).

Figure 2. Taiwan's seaports and container terminals
(Source: US Army Corps of Engineers, Army Geospatial Center (website), https://www.agc.army.mil/Maps/)

37. Soy Transportation Coalition, "Classes of Vessels and Cargo Capacity," n.d., accessed March 29, 2023, https://www.soytransportation.org/Stats/Ocean_VesselClasses.pdf.
38. "Lockheed C-5 Galaxy Heavy Military Transport Aircraft," Flugzeuginfo.net (website), n.d., accessed March 29, 2023, http://www.flugzeuginfo.net/acdata_php/acdata_c5_en.php.

In 2019, the Ports of Keelung and Kaohsiung accounted for 77 percent of the value of Taiwan's agricultural imports. In contrast, the Port of Taipei played a marginal role, with a 5 percent share (see table 2). Thus, it would be essential for Taiwan to keep these ports operational or to expand their capacities to sustain food resupply operations.

Table 2. Value of Taiwan's 2019 agricultural imports by ports
(Source: Trade Data Monitor (website), https://www.tradedatamonitor.com/)

Port	Value (USD)	Share
Keelung	11,946,303,244	43.31%
Kaohsiung	9,369,524,621	33.97%
Taichung	4,793,120,684	17.38%
Taipei	1,476,199,870	5.35%
Total	**27,585,148,418**	**100%**

Trade data also shows that nearly 95 percent of agricultural imports arrived in Taiwan by sea routes, while the remainder was transported by air. Moreover, shipping containers accounted for 85 percent of the value of agricultural products transported by sea, with the remaining goods coming in bulk (see table 3). These shares vary widely across agricultural products. For example, a larger share of corn and soybean imports came in bulk, whereas 100 percent of vegetables, palm oil, and dairy products were transported in containers—some of which were refrigerated.

Table 3. Value of Taiwan's 2019 agricultural imports transported by sea and by subcategories
(Source: Trade Data Monitor (website), https://www.tradedatamonitor.com/)

By Sea Subcategories	Value (USD)	Share
Container	22,015,335,478	85%
Not container: bulk goods	3,762,047,076	14%
Not container: packed sundry goods	268,968,708	1%
Express delivery	46,649	0%
Mail	555,180	0%
Total	**26,046,953,091**	**100%**

Taiwan's heavy reliance on shipping containers represents another vulnerability because China is the world's top producer and exporter of shipping containers. Furthermore, Chinese companies now produce

80 percent of new containers, and China is the world's top handler of containers.[39] As a stark reminder of this risk, during the COVID-19 pandemic and its associated supply-chain disruptions, freight container rates on the Chinese-US East coast route increased by more than 500 percent and triggered important changes in the flow of goods worldwide.[40]

Scenario 3: The United States and its allies foresee an impending Chinese naval blockade and begin coordinating food resupply operations before the blockade is enforced.

The last scenario involves the United States anticipating an imminent Chinese military invasion or naval blockade of Taiwan. In this case, the United States and its allies would have a limited window of opportunity to supply Taiwan with as many foodstuffs as possible before the disruption of maritime traffic to the island. Thus, time is essential, and Taiwan and its allies would have to contract or mobilize additional civilian and military maritime transportation rapidly to bring in additional food supplies before the conflict or blockade began.

Lieutenant General James W. Bierman Jr., commanding general of the III Marine Expeditionary Force and of Marine Forces Japan, stated that the United States and its Asian allies are attempting to replicate the groundwork done in Ukraine to support resistance against a Chinese invasion of Taiwan. This theater setting includes the pre-positioning of supplies and the identification of sites from which the United States and allies would support and sustain operations in Taiwan. Given its geographic proximity, the Philippines emerges as a suitable staging ground for the rapid deployment of US logistical assets.[41]

With limited time and logistical capacity, the United States and its allies would have to prioritize the transportation of the previously mentioned food products that would be critical for Taiwan to endure a prolonged conflict or naval blockade.

Finally, Taiwan would need sufficient infrastructure and supply-chain channels to receive, store, and distribute the sudden spike in imports

39. "How Dominant Is China in the Container Port Business?" *Zeymarine* (blog), April 14, 2022, https://zeymarine.com/how-dominant-is-china-in-the-container-port-business/.
40. Roslan Khasawneh and Muyu Xu, "China-U.S. Container Shipping Rates Sail Past $20,000 to Record," Reuters (website), August 5, 2021, https://www.reuters.com/business/china-us-container-shipping-rates-sail-past-20000-record-2021-08-05/.
41. Kathrin Hille, "US Military Deepens Ties with Japan and Philippines to Prepare for China Threat," *Financial Times* (website), January 9, 2023, https://www.ft.com/content/bf5362de-60a6-4181-8c2a-56b50be61383.

of voluminous food commodities. Otherwise, many of the precious imports may spoil and go to waste due to the vessels' long waiting periods at the shore, improper handling, or inadequate storage capacity.

Conclusions

For political and strategic reasons, food self-sufficiency and food security have been central issues in Taiwan's agricultural policy since the country established its independence. A declining agricultural sector and changes in diets and consumption patterns have made Taiwan more dependent on imported foods to meet its nutritional needs. Today, food imports account for more than two-thirds of Taiwan's annual caloric intake. This fact represents a major vulnerability since a Chinese military conflict and possible naval blockade would disrupt all commerce to and from the island. As a RAND report states, China would likely consider a naval blockade a lower-cost and lower-risk alternative to a full invasion of Taiwan. Furthermore, the report argues that any US or allied efforts to break the blockade would likely be unsuccessful and that China could endure the consequences of a prolonged confrontation much better.[42]

Reducing Taiwan's dependence on food imports would lessen Chinese leverage and buy Taiwan and the United States more time to consider military and diplomatic options. As shown here, Taiwan maintains sufficient food stocks to feed its population for six months. Steps to strengthen the island's food resiliency must improve domestic food production, expand food stocks, and plan for food resupply operations. Each of these options, however, comes with significant challenges.

This study identified food commodities (such as feed grains, animal proteins, and chemical inputs) that Taiwanese and American military planners should prioritize in pre-conflict stock buildup or resupply operations based on insufficient domestic production and the commodity's nutritional role in the Taiwanese diet. Then, three scenarios explored and assessed the ability of Taiwan's food supply chain to endure a partial or total Chinese naval blockade.

For the scenario assuming a total blockade, several solutions were discussed, including expanding food strategic reserves and increasing domestic food production prior to any level of conflict. Proposed strategies for boosting and decentralizing food production included the

42. Bradley Martin et al., *Implications of a Coercive Quarantine of Taiwan by the People's Republic of China* (Santa Monica, CA: RAND Corporation, 2022), https://www.rand.org/content/dam/rand/pubs/research_reports/RRA1200/RRA1279-1/RAND_RRA1279-1.pdf.

implementation of a victory garden program or promotion of closet gardens via hydroponic production.

In the second scenario, where China imposes a long naval blockade but allows a limited influx of food products to Taiwan, it is unclear whether commercial shipping companies would risk operating in that area. Under these circumstances, the United States and its allies may need to fill in the gap and mobilize naval and air assets to transport food safely to Taiwan. Transportation of the necessary volumes would require a large number of vessels capable of carrying bulk cargo or containers.

In the scenario where Taiwan and the United States believe China will enforce a blockade, Taiwan and the United States would have to coordinate food resupply operations—while possible—in an expeditious way. Again, this situation would involve the mobilization of a large fleet of cargo vessels, the pre-positioning of supplies, and the identification of sites from which the United States could coordinate resupply operations. Finally, the success of these efforts would depend on Taiwan's ability to handle, store, and distribute the sudden influx of large volumes of food commodities.

Gustavo F. Ferreira

Captain Gustavo F. Ferreira is a senior agricultural economist with the US Department of Agriculture and serves as an agricultural officer (38G) at the 353rd Civil Affairs Command, US Army Reserves. He holds a PhD in agricultural economics from Louisiana State University, and prior to joining the federal government, he was an assistant professor in agricultural economics at Virginia Tech University. He has published numerous research articles in top-ranking economics and military journals.

Jamie A. Critelli

Major Jamie A. Critelli, US Army Reserve, is a Civil Affairs officer serving as an agricultural officer in the 353rd Civil Affairs Command. He is a seasonal farm business owner and has worked in agriculture on five continents. He also serves as the director of the Operational Excellence Department at Memorial Sloan Kettering Cancer Center. He graduated with honors from Cornell University with a degree in horticulture and holds an MBA in supply-chain management from ETH Zurich.

Selected Bibliography

"America and China Are Preparing for a War over Taiwan." *Economist* (website). March 9, 2023. https://www.economist.com/briefing/2023/03/09/america-and-china-are-preparing-for-a-war-over-taiwan.

Andoko, Effendi, Wan-Yu Liu, Hua-Jing Zeng, and Agnes Sjöblom. "Review of Taiwan's Food Security Strategy." Food and Fertilizer Technology Center for the Asian and Pacific Region (website). September 10, 2020. https://ap.fftc.org.tw/article/2570.

Beckman, Alex. "Opportunities for U.S. Agricultural Exports in Taiwan, International Agricultural Trade Report." Foreign Agricultural Service/U.S. Department of Agriculture (website). April 8, 2019. https://www.fas.usda.gov/data/opportunities-us-agricultural-exports-taiwan.

Cancian, Mark F., Matthew Cancian, and Eric Heginbotham. *The First Battle of the Next War: Wargaming a Chinese Invasion of Taiwan*. Washington, DC: Center for Strategic & International Studies, January 2023. https://www.csis.org/analysis/first-battle-next-war-wargaming-chinese-invasion-taiwan.

Ho, Ching-Hsien, Huu-Sheng Lur, Ming-Hwi Yao, Fang-Ching Liao, Ying-Ting Lin, Nobuyuki Yagi, and Hsueh-Jung Lu. "The Impact on Food Security and Future Adaptation under Climate Variation: A Case Study of Taiwan's Agriculture and Fisheries." *Mitigation and Adaptation Strategies for Global Change* 23, no. 3 (March 2018). https://doi.org/10.1007/s11027-017-9742-3.

Knerr, Béatrice. "Food Security vs. WTO Membership in Taiwan." *Proceedings of the 3rd Annual Conference of the European Association of Taiwan Studies (EATS)*. Paris, EATS, March 2006.

Mainardi, Benjamin E. "The People's Republic of China at Sea: A Sea Power Ascendant?" *Strife Journal* 17 (Winter 2022).

Sharma, Nisha, Somen Acharya, Kaushal Kumar, Narendra Singh, and O. P. Chaurasia. "Hydroponics as an Advanced Technique for Vegetable Production: An Overview." *Journal of Soil and Water Conservation* 17, no. 4 (January 2019). https://www.researchgate.net/publication/330080392_Hydroponics_as_an_advanced_technique_for_vegetable_production_An_overview.