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Food Insecurity in the Oceania Region

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Disclaimer

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Executive Summary

Purpose

This report examines the role climate change plays in food security and how extreme climate events such as drought, flooding, and storms impact food security within the Oceania region. The focus is on how climate change impacts agriculture and, thus, how it impacts the four pillars of food security (i.e., availability, access, utilization, and stability) within ten countries of the Oceania region: Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Samoa, the Solomon Islands, Tonga, Tuvalu, and Vanuatu. A qualitative approach incorporating the use of descriptive statistics and storytelling was used to answer our research question, “How has climate change impacted food security in the Oceania region?” The report concludes with four policy recommendations to address climate change and food insecurity within the Oceania region.

Key Takeaways

- Within climate change phenomena, climate variability and climate extremes are among the most critical components that substantially impact food systems and food security within the countries examined in this report.
- Climate extremes and variabilities such as drought, flooding, intensive rainfall events, and storms have detrimental effects on the four food security pillars and threaten food security throughout these ten Oceania countries.
- Climate extremes limit the availability of food items, hamper an individual’s ability to access healthy and nutritious food options, and destabilize the food system.
- Many individuals in these countries rely on imported food, and even the slightest disruption in the supply chain can have a trickle-down effect eroding food security throughout these countries.
- Further research is needed to address gaps in literature, including available data, which is often insufficient, outdated, aggregated, or not uniform.

Recommendations

- Increase educational awareness and opportunities for farmers to sustain their livelihood through the use of traditional food practices and climate-resilient crops.
- Invest in infrastructure including materials, supplies, and equipment that can aid and increase food production, sustain long-term food storage, and minimize food spoilage and waste.
- Implement and promote incentives for farmers and citizens to support the local food production industry.
- Develop and build resiliency through public and private partnerships by expanding upon regional and international efforts to strengthen the food security pillars within the Pacific Region.

Introduction

In 2020, more than 30% of the global population was considered food insecure. The Food and Agriculture Organization (FAO) of the United Nations (UN) states that “food security exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary and nutritional needs and food preferences for an active and healthy life” (FAO et al., 2021; World Food Summit, 1996, para. 2; Coleman-Jensen et al., 2022; Rabbitt and Smith, 2021). On the other hand, food insecurity occurs when people lack “regular access to enough safe and nutritious food for normal growth and development and an active and healthy life” (Food and Agriculture Organization of the United Nations, 2022, para. 4). Food insecurity can have a range of devastating impacts on an individual’s health, such as chronic hunger, malnutrition, anemia, lower nutrient intake, cognitive problems, and mental health issues (Pacific Community & World Food Programme, 2018; Gundersen and Ziliak, 2015).

Climate variability and extremes “create multiple, compounding impacts on food systems that negatively affect food security and nutrition” (FAO et al., 2021, p. 54). Thus, it is essential to understand climate change impacts when discussing climate change-induced food insecurity. For example, drought greatly changes vegetation and thus reduces the supply of plant-based food for both human and livestock consumption. This reduction not only reduces the food supply but also results in lost agricultural revenue. Moreover, droughts reduce the supplies of both fresh drinking water and water to irrigate crops, creating increased competition for available water and contributing to land degradation. Meanwhile, erratic and unusually heavy rainfall can erode fertile topsoil, thereby diminishing crop productivity and disrupting the distribution and exchange of crops. As these examples show, the food system is incredibly vulnerable to changes in climate.

Food Security and Food Insecurity Defined

Food impacts every aspect of daily life; it satisfies our hunger and allows us to connect and share with other human beings. The FAO and the World Food Summit outline four pillars as integral to achieving food security across nations; these pillars are food availability, food access, food utilization, and stability of the food system.

First, food availability refers to an adequate supply of food that is rich in nutritional value, is high quality, and can be supplied through local production or imports. Essentially, the availability of sufficient food is necessary to sustain the world’s population and to “sustain a steady expansion of food consumption and to offset fluctuations in production and prices” (FAO, 2006, p. 1). Second, food access refers to individuals’ access to the necessary resources to acquire nutritious food options and supplies. This food pillar is defined as “ensuring that all people at all times have both physical and economic access to the basic food that they need” (FAO, 2006, p. 1). Third, food utilization refers to how individuals use their access to food to consume a nutritious and adequate diet that meets their needs. The food utilization pillar signifies that an individual with the necessary resources and services is able to meet nutritional needs, including clean drinking water, sanitary facilities for food preparation, and health care options. These components aid in ensuring food is prepared safely and that those preparing meals

maintain proper hygiene.

The fourth pillar is the stability of the food system. A stable food system will allow an individual, household, or community uninterrupted access to and means to acquire food supplies to be able to consume the right quantity and quality to meet their nutritional requirements (FAO, 2006). An unstable food system is vulnerable to climate change impacts, thereby affecting food availability, food access, and food utilization, all of which lead to food insecurity.

An individual who is severely food insecure has “run out of food and gone a day or more without eating,” while an individual who is moderately food insecure “might have to sacrifice other basic needs, just to be able to eat” (Moncayo & Cafiero, 2022, para. 5-6). Severe food insecurity is generally an indicator that an individual has experienced hunger, while moderate food insecurity means that access to food is in question. Although moderate food insecurity does not necessarily entail hunger, it does suggest that food consumed is cheap and of low nutritional quality. While severe food insecurity is associated with hunger, moderate food insecurity can lead to obesity, malnutrition, sickness, and noncommunicable diseases in the long term (Moncayo & Cafiero, 2022).

The facets of food insecurity are many and may include insufficiency in the total supply of food, volatile food prices, and what quantities and types of food are imported by a country. Furthermore, the cost of labor and local production are related to the cost of food and may affect the functioning of the local market, which could hinder people’s ability to purchase food (Barnett, 2010). Additionally, the inability of a household to grow its own food, considered a micro-level component of the food system, has repercussions for both physical and financial health.

Overview of Climate Change in the Oceania Region

Food security is substantially and negatively affected by climate change; climate variability and climate extremes have especially notable impacts. Climate variability is linked to a range of natural phenomena including drought, flooding, and changes in the ocean and air, and occurs when the different climate components, such as precipitation or temperature, vary from the normal climate (Climate Variability | Center for Science Education, 2022). Countries that experience climate extremes can face drought, heat spells, dry spells, frosts, precipitation, flooding, or storms, as well as increased ambient air or sea-surface temperatures (Frank et al., 2015).

Climate change threatens the food security of people living in areas such as Oceania that already experience frequent extreme weather events and whose populations rely heavily on agriculture for their livelihoods (Ahmed et al., 2011). Currently, 70% of Oceania’s population relies on agriculture and fishing as their main source of income. These livelihoods are incredibly sensitive to changes in rainfall and general climate variability, two elements known to be impacted by climate change (Pacific Community & World Food Programme, 2018).

Oceania encompasses Australia, New Zealand, and three diverse regions: Melanesia, Micronesia, and Polynesia. Collectively, climate change will increase the vulnerability of Oceania to both climate variability and climate extremes. In particular, drought and heavy rainfall events pose significant threats to the region at-large while soil degradation threatens arable land and associated agricultural production (CSIRO et al., 2015). These changes will negatively impact the water security, agriculture, forestry, fisheries, and overall ecosystems of the island states of the region. With a growing population, increased

urbanization, high poverty, and chronic hunger, Oceania sits at a particularly vulnerable position when it comes to meeting the dietary needs of its communities (Morrell & El-Hage Scialabba, 2009).

In addition to weather-related factors, Oceania faces dire risks as some countries lie just meters above sea level. Sea level rise poses both a current and future threat to the region as sea level rise leads to soil salinization through saltwater intrusion, which negatively impacts the productivity of already limited agricultural land. Sea level rise also poses a threat to coastal infrastructure such as ports and harbors and leads to higher storm surges. These threats also carry a financial burden; one mid-range projection is that a 50-centimeter (19.6-inch) sea level rise over 77,000 kilometers (47,800 miles) of Pacific Island coastal communities translates to a direct cost of almost US\$1.5 million (Bright et al., 2018).

This report examines the influence that climate change, specifically climate extremes and variability, has on food security, specifically on agricultural land, in Oceania. The concepts of climate change, food security, and food insecurity are defined. The report examines climate change-induced food insecurity impacts in ten countries located in Oceania: Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Samoa, the Solomon Islands, Tonga, Tuvalu, and Vanuatu. Four policy recommendations are proposed to address climate change and food insecurity within the Oceania region.

Literature Review

The Effect of Climate Change on Food Systems, Security, and Insecurity

Climate change has reduced and will continue to reduce agricultural production and negatively impact the food system by reducing food availability, access, and utilization which will introduce instability in a variety of ways (Lobell et al., 2008; Brown and Funk, 2008; Mbow et al., 2019). Climate extremes can cause severe agriculture losses, which can affect the well-being of the people as well as the financial stability of the farming community. Production can be threatened by soil erosion and the lack of freshwater, which can severely limit the resources available to farmers. Severe weather events, such as tropical storms and hurricanes, can affect infrastructure and negatively affect the availability of farm inputs. These events can also limit the production and transportation of food to domestic markets, thereby limiting farmers' ability to participate in the agriculture sector and resulting in financial losses (Dawson, McGregor and Taylor, 2016).

The impacts of climate extremes and climate variability are already contributing to rising food insecurity globally. Understanding these impacts is essential to understanding how climate change affects food systems (FAO, 2021). For example, drought greatly changes vegetation and thus reduces the supply of feed crops for livestock. As a result, livestock production falls and not only disrupts the food supply but also leads to a loss of revenue. Moreover, droughts reduce supplies of water for both human consumption and irrigation, and the results are increased demand for water and land degradation. Concurrently, erratic and unusually heavy rainfall, especially short, high intensity events, erodes fertile topsoil, an effect that diminishes crop cultivation and disrupts distribution and exchange of crops. As the above examples highlight, the food system is incredibly vulnerable to changes in climate.

As populations move from rural to urban settings for various reasons including for access to food, diets tend to change from traditional foods to a greater reliance on imported food; the result is often that less food is grown in the country and more food is brought in from elsewhere. A country whose population is largely dependent on imported food may have entire communities that are especially vulnerable to changes in both food supply and food prices, the latter because these countries remain too small to exert a significant influence on global food markets (United Nations Development Programme, 2012). Food consumption is tied to the ability to pay for higher priced food, and the inability to pay for quality results in a shift to cheaper and less nutritious food options, a shift that increases the number of malnourished people (Mbow et al., 2019).

Finally, relying on imported foods means relying on transportation systems. Oceania relies heavily on food transportation systems because of the distance between and within countries, especially in more rural island communities. Extreme climate events can impact infrastructure including both transportation systems and traditional storage. Farmers will either find new methods of storage such as refrigeration or air conditioning or their crops will spoil. In sum, climate change is expected to significantly affect the global food supply in the coming years, and it will have an impact on each of the four food pillars, thereby increasing food insecurity.

More broadly, climate change impacts on food security can reverberate beyond farmers and other local food producers. A reduction in supply or disrupted supply lines can cause spikes in prices that can have both social and political changes. Climate extremes and volatile food prices are often accompanied by economic downturns in countries that have experienced conflict or environmental disasters (FAO et al., 2021). Climate extremes, when combined with internal socio-economic and political complexities and conflicts, can potentially destabilize governance systems. Stronger governments may have the ability to control and determine regional food systems, supply chains, and the price of resources, but unstable and fragile governments can become dependent upon stronger governments for food supplies and resources. This dynamic can put national sovereignty and security at risk. The interconnectedness of conflict, economic downturns, and climate extremes highlights the key role that climate plays in regional and global stability.

Climate Change Impacts on Food Security in the Oceania Region

The Pacific Ocean covers nearly one-third of the earth's surface and encompasses over 10,000 islands with a combined land area of approximately 8.5 million square kilometers (sq km; 3.3 million square miles) (About - Oceania | IUCN, 2022). As shown in Figure 1, the Oceania region spans the Pacific Ocean and covers over 100 million sq km (38.6 million square miles) and is home to 14 countries (Countries in Oceania, 2022).

With an estimated population of 43.5 million people, Oceania is home to just 0.54% of the world's total population (Population of Oceania, 2022). The countries in Oceania share characteristics with other developing nations, such as a growing population and scant resources, small or no economies of scale, frail ecology, exposure to disasters, and an overdependence on international trade (UNESCO World Heritage Convention).

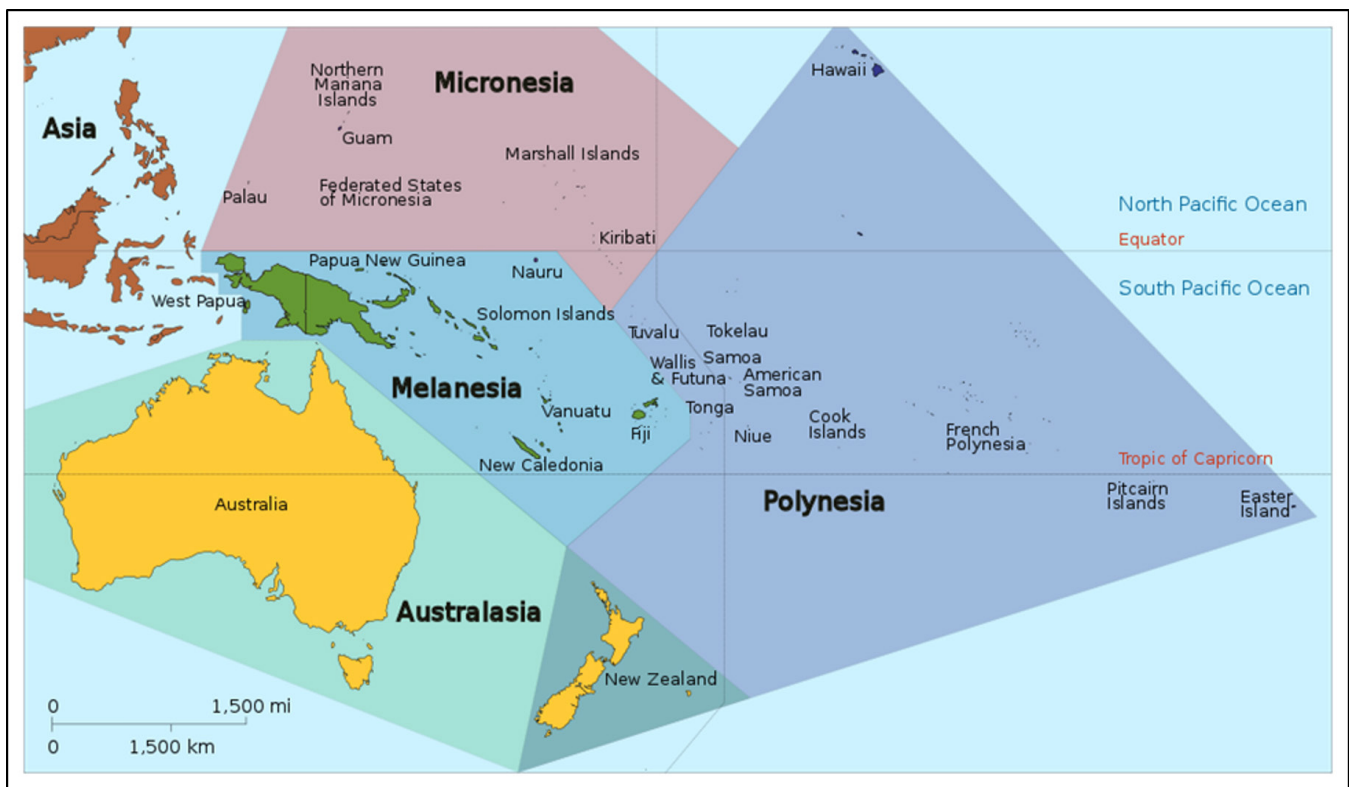


Figure 1. Map of Oceania (Source: United Nations)

While contributing just 0.03% of global greenhouse gas emissions, the people of Oceania are extremely vulnerable to the impacts of climate change (Thomas, 2020). Climate change-induced food insecurity has already started impacting many lives in these countries. The ability to have continuous and consistent access to a healthy and nutritionally balanced food supply is an ongoing challenge and rising threat for Oceania's people. Food security and economic development are difficult in the region because of the limited land that is suitable for agriculture, population migration from rural to urban centers, great distances between main food markets and island-consumers, limited commodity exports, and high vulnerability to natural disasters (Vanuatu, 2022).

Food insecurity is exacerbated by a heavy dependence on imported food in the region alongside particularly fragile infrastructure. Many Oceania countries lack critical infrastructure such as paved roads, shipping facilities, cold storage facilities, physical market spaces, and safe transportation, and all of these factors limit the shelf life of food while also lowering its quality. Especially in smaller, more remote islands, common in this region, high costs involved in transporting food can be prohibitive (United Nations, 2021; Cauchi et al., 2019). Regular climate shocks create disruption to the food supply, increasing the cost of food and restricting the availability and accessibility of food sources. Economic instability as a result of climate extremes, damage to infrastructure, and cost of recovery create bottlenecks in many regional countries' development.

Smaller atoll countries such as those within the Oceania region are particularly susceptible to coastal sea level rise, erosion, saltwater intrusion, and extreme weather events, which threaten the livelihoods of these communities. Climate change and food security are among the top challenges confronting countries in Oceania, and climate extremes are forecast to remain an issue in the region.

Methodology

This report examines the role climate change plays in food security and how extreme climate events impact food security within the Oceania region. The focus is on climate change impacts on agriculture and, thus, on the four pillars of food security (i.e., availability, access, utilization, and stability) within ten countries of the Oceania region.¹ A qualitative approach incorporating the use of descriptive statistics and storytelling was used.

Because this research was conducted in collaboration with the Center for Excellence in Disaster Management and Humanitarian Assistance (CFE-DM), an office that reports directly to the United States' Department of Defense Indo-Pacific Command (USINDOPACOM), this report focuses on ten countries under the INDOPACOM Area of Responsibility within the Oceania region: Fiji, Kiribati, Nauru, Niue, Papua New Guinea, Samoa, the Solomon Islands, Tonga, Tuvalu, and Vanuatu. These countries were selected for three reasons. First, they are all situated in the same region and are extremely vulnerable to similar impacts of climate change. Therefore, these countries can share, learn, and build upon each other's understanding to craft their security plans, measures, and developmental strategies. Second, the cultural values within these countries are centered around achieving regional tranquility, wealth, and well-being. Lastly, they all express a common sense of identity, values, and purpose, and they seek to achieve a deeper Pacific regionalism (The Pacific Islands Forum, 2022).²

Secondary data was collected from a variety of sources:

- Official reports published by international organizations (e.g., the UN, the FAO, the Intergovernmental Panel on Climate Change [IPCC], etc.);
- Governmental reports of the ten countries;
- Papers and reports completed by other community organizations, international aid organizations, and community groups; and
- Peer-reviewed journals, articles, and research papers.

Data was also collected from government records and information found on each country's official websites, data hubs, forums, and books.

For each country, collected data includes the number of islands or atolls, population, total land area, percentage of land used for agriculture, climate description, natural hazards, gross domestic product (GDP), per capita income, agriculture's contribution to GDP, percentage of population employed by the agricultural sector, percentage of import and export of food,³ percentage of population living below the global basic needs poverty line, percentage of the population suffering from undernourishment, percentage of population experiencing moderate or severe levels of food insecurity, and each country's WorldRiskIndex 2021 ranking.

Data was analyzed to determine how each country experiences food security impacts from climate variability and climate extremes. Each impact was categorized on the type of climate extreme (e.g.,

¹ Although we acknowledge that Oceania countries rely on fisheries as an important element of food security and that surrounding oceans have been and will be impacted by climate change, this is beyond the scope of this study.

² Other countries within the Oceania region including American Samoa, Australia, Cook Islands, French Polynesia, Guam, New Caledonia, New Zealand, Northern Mariana Islands, Tokelau, and Wallis and Futuna were excluded as each of falls into one of the following categories: The Five Eyes (FVEY), French territories, Compacts of Free Association (COFA), and United States territories and commonwealths.

³ Imported and exported food is categorized by the Standard International Trade Classification (SITC) in sections 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal, vegetable oils, and fats), and SITC division 22 (oil seeds, oil nuts, and oil kernels). (The World Bank, 2022).

drought, flooding, or storms) that impacted agriculture and land production and then categorized based on its effects on the four pillars of food security. Common themes were analyzed to generate policy-level recommendations to assist countries in addressing the consequences of climate change as it relates to food security.

Results and Findings

In addition to the country sections below, the findings have been summarized in Country Profile Tables 1-10 in Appendix A. The tables include population statistics, physical characteristics, current economic status, climate characteristics, and statistics on food insecurity. The four pillars of food security and impacts from climate extremes were also annotated.

Fiji

In addition to the country sections below, the findings have been summarized in Country Profile Tables 1-10 in Appendix A. The tables include population statistics, physical characteristics, current economic status, climate characteristics, and statistics on food insecurity. The four pillars of food security and impacts from climate extremes were also annotated. Fiji is an archipelago that comprises over 320 islands and 500 islets. However, only 110 of these islands are permanently inhabited, and the two major islands, Viti Levu and Vanua Levu, are home to most of Fiji's 898,402 people. Fiji has a total land area of 18,274 sq km (7,055 square miles) with the two large volcanic mountainous islands, Viti Levu and Vanua Levu, constituting 87% of the country's total land (Fiji, 2022; Pacific Climate Change Science, 2014). Of the total land area, 23% is dedicated to agricultural use (Fiji, 2022). Fiji has a tropical marine climate with very few temperature variations between seasons. The country receives a lot of rainfall and has warm weather patterns (Fiji, 2022).

Fiji is prone to cyclones, drought, flooding, and landslides. In fact, extreme climate events such as Tropical Cyclone Evan in 2012, Tropical Cyclone Winston in 2016, and other flooding events and drought-like conditions have taken lives, destroyed homes, and damaged agriculture and livestock systems, destruction that ultimately displaced communities and settlements. In addition to these events, sea level rise significantly impacts the development and socio-economic livelihoods of the Fijian population (Pacific Risk Resilience Programme, 2015).

Fiji has a total GDP of US\$9.86 billion and an annual per capita income of US\$5,058. While Fiji's agriculture sector is considered one of the country's major industries, employing over 44% of the total workforce, only 13.5% of the overall GDP is from agriculture (World Data Atlas, 2020; Pacific Climate Change Portal, 2022; Fiji, 2022).

Fiji's population is not heavily dependent on importation as the country only imports 22.46% of its food while exporting 60.02%. While food appears available, it is not always accessible as 30% of Fiji's total population lives below the global basic needs poverty line (World Data Atlas, 2019; Asian Development Bank, 2019; Fiji, 2022). An estimated 6% of the total population is suffering from undernourishment or malnutrition whereas 14% of the population is experiencing moderate to severe levels of food insecurity (The World Bank Group, 2022).

Due to the country's relatively low reliance on importation, Fijians heavily depend on traditional subsistence farming and marine ecology for their livelihoods, a situation that makes them extremely vulnerable and sensitive to climate change and market dynamics that affect not only the country's ecosystem but also the availability, accessibility, and utilization of food, and that ultimately threaten the stability of the entire food system. Indeed, Fiji was ranked the world's 14th most vulnerable country to disasters in the 2021 WorldRiskIndex (El-Zabri, 2022).

Fijians rely on precipitation for both drinking water and water used for irrigation. Shortages of freshwater due to drought-like conditions and dry spells affect agriculture and livestock practices and production. In fact, the drought-like conditions that occurred in 2016 and 2017 collapsed Fiji's agriculture system and production protocols due to a severe lack of water, which caused tremendous amounts of food insecurity throughout Fiji. During times of prolonged dry events, the population has been forced to change their diets to avoid getting sick. Some Fijians have started consuming unhealthy imported food. Other households rely on the produce of their relatives, neighbors, and community members to supplement their diets (Pearce et al., 2017). Although Fijians have adjusted their diets depending on what is available, the future is forecast to be even more challenging as climate change is expected to worsen the effects of drought and increase the frequency of extreme weather events (IPPC Report, 2013).

Kiribati

The Republic of Kiribati is a Pacific Island nation in Micronesia; it is composed of 33 scattered islands—32 coral atoll islands and one raised limestone island—extending over 3.5 million sq km (1.35 million square miles) of the Pacific Ocean and divided among three island groups: the Gilbert Islands, the Phoenix Islands, and the Line Islands. Of the 33 islands, only 20 are inhabited with a total population of 120,740 citizens (Kiribati, 2022; Secretariat of the Pacific Community, 2021). This archipelago has a total land area of only 811 sq km (313 square miles) with around 42% of its arable land dedicated to agriculture.

The climate in Kiribati is generally hot, humid, and tropical, moderated by trade winds, and with an average temperature of 27.5°C (81.5°F), which closely reflects the temperature of the surrounding ocean (The World Bank, 2021). While the average temperature is relatively constant year-round, the dry and wet periods vary from island to island because the archipelago extends across a vast area of ocean. Islands that belong to the Gilbert and Line Groups tend to experience more rainfall, whereas islands in the Phoenix Group tend to experience drier weather. Aside from climate extreme events, Kiribati also experiences natural hazards including typhoons, occasional tornadoes, and sea level rise.

Due to its limited natural resources, the country of Kiribati has been regarded as one of the least developed nations in the world with a GDP of US\$270 million and an annual per capita income of US\$2,300—the lowest GDP per capita of all the Pacific Island countries (Food and Agriculture Organization of the United Nations, 2021; United Nations, 2021; Kiribati, 2022). The agriculture sector contributes 23% of the country's overall GDP and employs 15% of the total labor force. Kiribati continues to have limited agricultural resources due to poor soil fertility, uneven distribution of rainfall, lack of knowledge on agricultural practices, poor commitment to gardening, and the loss of traditional knowledge for traditional foods, which have often been abandoned for seasonal fruits and vegetables

(United Nations, 2021; Ministry of Environment, Land and Agricultural Development, 2010). Local agricultural produce is insufficient to meet the needs of the growing population in Kiribati.

Kiribati imports 44% of its food and exports 84% of food (The World Bank, 2022). The country's heavy dependence on imported food and the challenging logistics of reaching the remote archipelago are already drivers of food insecurity, but the people of Kiribati also have limited purchasing power on the global market. Thus, the country is prone to food shortages and food insecurity. For example, in both 2004 and 2008, when the world experienced food and fuel price spikes, Kiribati experienced a food crisis after shipments failed to deliver essential food (Cauchi et al., 2019). With such a heavy reliance on importation, food security issues are magnified as 22% of the population lives below the global basic needs poverty line, 4% suffers from undernourishment, and over 40% experiences moderate to severe levels of food insecurity (The World Bank, 2022).

Due to its low-lying profile, rising just 3-4 meters (9-13 feet) above sea level, and its extreme vulnerability to climate change, Kiribati is considered the world's 19th most vulnerable nation to disasters by the WorldRiskIndex 2021 (The World Bank, 2021; Mucke et al., 2021). Kiribati has often been described as, "a textbook case of inherent climate vulnerability with limited land area, overcrowding, low elevation of islands and water insecurity exacerbating public health problems" (Cauchi et al., 2019, p. 1).

Nauru

The Republic of Nauru is the smallest island country in the world, located in the South Pacific Micronesian region. This single-island country has a population of 11,832 citizens and a total land area of 21 sq km (8.1 square miles) (Nauru, 2022; Nauru, 2022; Secretariat of the Pacific Community, 2021; The World Bank, 2021). Nauru is known for its unique phosphate rock environment and is characterized by its remoteness, fragile biodiversity, and limited natural resources (Nauru, 2022; Department of Commerce, Industry, Trade & Environment, 2021). Only 20% of the island is habitable and suitable for agricultural cultivation due to harmful environmental impacts from phosphate mining that began in 1907 (Nauru, 2022;). The environmental impacts of phosphate mining have left most of Nauru's inland area, about 80% of the island, uninhabitable, unsuitable for agriculture, and ecologically degraded. As a result, the entire population of Nauru lives on the narrow, low-lying coastal area where they are extremely vulnerable to the impacts of climate change (The World Bank, 2021).

Nauru has a tropical climate with a monsoonal pattern; it experiences a consistent average temperature of 28°C (82.4°F) that is intrinsically tied to its surrounding ocean temperatures. Nauru's wet season is typically between November and April, while its dry season occurs from May to October (The World Bank, 2021). However, the tropical climate and variable rainfall pattern can lead to extended periods of drought, which have lasted as long as 36 months. Nauru is only 52 kilometers (33 miles) south of the Equator, in an area of frequent cyclone formation (The World Bank, 2021; Australian Government, 2015).

Nauru has a GDP of US\$150 million and an annual per capita income of US\$13,500 (Nauru, 2022). Only 6% of the country's GDP comes from the agriculture sector, which is aligned with the labor force as most of Nauru's population is employed within the public sector in education, administration, or transportation or within the mining industry with very few people employed in agriculture.

Since Nauru imports over 90% of its food, the stability of Nauru's food system and food security is fragile (The World Bank, 2021). Nauru is also particularly vulnerable to droughts and extreme rainfall,

flooding, and storm surges because of its very limited groundwater resources. These resources are at risk when climate extremes such as flooding and extreme rainfall events lead to contamination and vector-borne disease outbreaks. The country heavily depends on rainwater collection tanks, storage, and treatment infrastructure that are primarily located in the coastal zone, and the island is constantly at risk of being unable to meet its drinking water and food hygiene demands. Extreme rainfall events and rainfall delivered in short, high intensity events prohibit rainwater harvesting and can potentially damage vital water storage systems and, therefore, the ability to frequently replenish water (The World Bank, 2021). These issues are exacerbated by flooding and extreme rainfall events.

Niue

Niue is an independent state in free association with New Zealand as recognized by the UN. This single-island state is one of the world's largest coral atolls, located in the Southwestern Pacific Ocean, with a population of 1,549 people. Located in a triangle between Tonga, Samoa, and the Cook Islands, and famously known as “The Rock” or “the Rock of Polynesia,” Niue has a total land area of 260 sq km (100 square miles) with only 19.1% of the land area dedicated to agricultural use. Due to its geographic location in the southeast trade winds’ zone and on the end of a tropical cyclone belt, Niue often experiences gale force winds. During its hot season, which usually runs from June to September, Niue has high temperatures and humidity. On the other hand, the cool season, which usually runs from October to February, is characterized by warm sunny days and cool nights (Niue Meteorological Service, 2000).

Niue’s overall GDP is US\$10.01 million with an annual per capita income of US\$5,800. Of the total GDP, 23.5% is from the agriculture sector, which employs over 85% of Niue’s total labor force. Thus, agriculture is integral to not only the food production system but also the overall livelihood of Niue’s population. The main staple food items in Niue are taro and other local vegetables such as spinach. Aside from these, the country produces various fruits and vegetables such as yams, cassava, watermelon, and kumara (Fukofuka, 2015). The diversity in crop selection is extremely limited, and some products are unavailable at times due to poor soil conditions, high input costs, inferior irrigation systems, and limited farming supplies, particularly during extended periods of drought.

According to Handmer (2012), climate extremes have the potential to seriously affect the water management system on the island and to cause devastating impacts to infrastructure by impairing food production, storage, and delivery systems. As mentioned, taro is the main staple food item for Niuean households. Due to the lack of irrigation, harsh weather conditions such as droughts, cyclones, and intense rainfall events, and coastal erosion, which pollutes water sources, the roots of taro crops will wither, resulting in crop failure (Niue Meteorological Service, 2000).

To offset the levels of food insecurity due to crop failure, over 70% of households keep livestock for their subsistence (Fukofuka, 2015). Thus, most households are subsistence farmers to supplement their food purchases as 13% of the population lives below the global basic needs poverty line. Food purchased from domestic markets is often supplemented by local poultry and egg production. However, the single most imported item in 2013 was frozen chicken, representing nearly 30% of all food imported to Niue (Fukofuka, 2015). This validates that Niue heavily relies on imported food rather than local food supply in order to adequately feed its population.

Despite Niue’s favorable climate for agricultural production, the country is still extremely vulnerable to the effects of climate change, which threatens its food systems. Moreover, Niue does not have any surface

water and exclusively depends on rainwater to infiltrate and recharge the island's groundwater. Research predicts that the effects of drought conditions will have tremendous long-term impacts on the island's water systems.

Local agricultural production is improving but is not sufficient to meet the needs of the population (Fukofuka, 2015). To address this issue, the government of Niue formulated its 2015-2019 Agriculture Sector Plan. The plan aims to improve food security throughout Niue by promoting sustainable food production and agriculture (Niue Agriculture Sector Plan 2015–2019, 2019).

Papua New Guinea

Papua New Guinea (PNG) is a tropical and mountainous island nation that encompasses the eastern half of the island of New Guinea and some 600 islands or atolls (Pacific Climate Change Portal [PCCP], 2022). PNG has a population of over 9.1 million people spread across the archipelago, which has a total land area of 462,940 sq km (178,742 square miles). Of the total land area, only 2.6% is dedicated to agricultural use. PNG's climate is tropical with monsoonal patterns and seasonal temperature variations. However, PNG is often hot, humid, and foggy year-round with modest differences in atmospheric conditions. The archipelago is subject to cyclones, flooding, landslides, earthquakes, coastal erosion, drought, and frost (Global Security Organization, 2022). Research has shown that these climate conditions are affected by El Niño, which will cause extreme climate events to be less frequent but more intense (Jacka, 2019).

The country's GDP stands at US\$36.69 billion with an annual per capita income of US\$2,757 (World Data Atlas, 2022). The agriculture sector accounts for 22.1% of the country's GDP and employs over 85% of its total workforce. Being able to employ such a large number of people is a huge factor that has helped keep the country's reliance on importation relatively low as it imports only 11.03% of its food. On the other hand, PNG exports 27.07% of its food (Papua New Guinea, 2022; World Data Atlas, 2022). Around 39.90% of its population lives below the global basic needs poverty line with 24.6% experiencing undernourishment or malnourishment (Asian Development Bank, 2017).

Based on the 2021 WorldRiskIndex, PNG ranks as the world's 9th most vulnerable country to disasters (Mucke et al., 2021). Every year, PNG experiences intense inland-coastal flooding, landslides, and sea level rise, resulting in damage to infrastructure and livelihoods (Global Security Organization, 2022). Within the last two decades, coastal torrential rain events have led to intense flooding that has hurt and killed people and displaced communities throughout the country with an approximate economic loss of US\$10.20 million annually (Global Security Organization 2022).

Other extreme climate events including Tropical Cyclone Ita in 2014 have destroyed infrastructure and disrupted water and food supplies, which limited food availability and accessibility in PNG. Similarly in 2015, over 2.4 million people (40% of the population) were impacted by acute shortages of water due to cold and frost, which limited irrigation and the availability of freshwater to prepare food safely. Such events hinder the ability to plant and cultivate crops and may result in crop failure due to the prolonged absence of water after icing, especially in places located at higher elevation. For instance, sweet potatoes usually fail to grow and thrive even after replanting due to the presence of too much nitrogen accumulation in the soil in absence of required precipitation (Bourke, 1988).

Food shortages affect the overall functioning of the food market as prices of critical commodities may double or even triple. For example, after a particularly strong El Niño event in 1972, sweet potato, which

is the staple food of the country, tripled in price, while the price of rice spiked over 22%. In response to this crisis, the Australian Government began promoting the cultivation of Irish potatoes, a frost-tolerant crop that can mature in three to six months, more swiftly than the sweet potatoes which typically mature in nine to twelve months (Jacka, 2019). Beyond this type of external intervention, during food crises, communities have resorted to consuming other food items such as cabbage and tree fern leaves as main components in their diet. Other climate smart and cold resilient crop varieties with longer shelf lives have been introduced for climate change adaptation and to mitigate acute food shortages. Such immediate efforts and practical actions at the individual level play a pivotal role in mitigating food insecurity during food crises.

Samoa

Located between Hawai‘i and New Zealand, the independent state of Samoa lies in the Southwest Pacific and comprises two large volcanic islands (Upolu and Savai‘i) and nine smaller islands with a total population of 199,853. Samoa has a total land area of 2,831 sq km (1,093 square miles) with 12.4% of the land dedicated to agricultural use; in detail, 2.8% is used for producing coconuts, bananas, yams, coffee, and cocoa, permanent crops such as taro take up 7.8%, and permanent pastures take up the remaining 1.8% (CIA Factbook, 2022).

Samoa’s climate is tropical and humid with consistent temperatures throughout the year and high rainfall during the wet season, which typically runs from November to April whereas the dry season runs from May to October. While there are significant differences in rainfall from season to season, Samoa is prone to unusually long dry spells and drought-like conditions and is at risk of occasional cyclones and volcanic activity (Samoa, 2022; The World Bank, 2021).

Samoa’s overall GDP is US\$1.25 billion with an annual per capita income of US\$6,300 (Samoa, 2022). In Samoa, food is an important component of culture as it is used as a symbol of care and respect; in this regard, the culture influences the country’s agricultural sector, which makes up 10.4% of Samoa’s GDP and employs 65% of the workforce. Samoa exports nearly 65% of its food and imports 25.47% of its food. In 2019, despite 20.30% of the population living below the global basic needs poverty line, only 4.60% of the population were suffering from undernourishment. Concurrently, 23.60% of the population was experiencing moderate to severe levels of food insecurity.

When it comes to disaster risk, Samoa ranked among the least vulnerable to disasters, at 109 of 181 countries in the 2021 WorldRiskIndex (Mucke et al., 2021). Nonetheless, disasters do occur. In 2012, Tropical Cyclone Evan caused massive damage to crops, severely damaged agricultural land, and impacted the country’s water distribution facility (Fakhruddin, Babel and Kawasaki, 2015). In fact, Samoa has a uniquely fragile water system including wells, springs, and rainwater collection tanks that serve roughly 95% of the population and is vulnerable to the impacts of climate extremes.

The Solomon Islands

The Solomon Islands are an archipelago formed of volcanic islands and low-lying coral atolls and reefs situated in Melanesia. The Solomon Islands are divided into nine provinces with six major islands:

Choiseul, Guadalcanal, Malaita, Makira, New Georgia, and Santa Isabel (Solomon Islands, 2022; United Nations, 2022). In addition to these six major islands, there are over 900 small islands, low-lying coral atolls, and reefs dispersed across 854,046 sq km (329,749 square miles) of the Pacific Ocean (Solomon Islands, 2022). Only one-third of the islands are inhabited by the country's 728,041 people (Solomon Islands, 2022; Solomon Islands, 2022; Secretariat of the Pacific Community, 2021). The Solomon Islands have a total land area of just 28,230 sq km (10,900 square miles) with 3.90% of the land dedicated to agriculture.

The Solomon Islands experience a very stable tropical monsoon-like climate with few temperature extremes and average temperatures of 24.5-26.5°C (76.1-79.7°F) year-round with two distinct seasons—a wet season from November to April and a dry season from May to October (The World Bank, 2021). Temperatures across this archipelago are strongly tied to changes in the surrounding ocean temperatures and are subject to the effects of both El Niño and the West Pacific Monsoon. Due to their position in an active geological and hydrometeorological region, the Solomon Islands are constantly exposed to various extremes, such as intense periods of rainfall, thunderstorms, extreme droughts, heatwaves, floods (coastal, fluvial, and flash), king tides, earthquakes, tsunamis, volcanic activity, and tropical cyclones. These can all have a significant impact on food sources and supplies within the country (Australian Government, 2015).

The Solomon Islands' GDP is US\$1.71 billion with an annual per capita income of US\$2,500. The agriculture sector contributes 34.3% of the country's overall GDP and employs about 75% of the total workforce (Solomon Islands, 2022). The productivity of small-scale agriculture is very important to the Solomon Islands' population as it allows them to maintain food security and household income. In fact, the Solomon Islands only imports 22.19% of its food and exports 20.15% of its food.

The Solomon Islands is amongst the world's poorest countries with 12.70% of the population living below the global basic needs poverty line (The World Bank, 2022). Undernourishment and malnutrition continue to be a serious issue throughout the country. In 2019, 16.50% of the population reported being undernourished (The World Bank, 2022). Another study reported that 1 in 10 people throughout the country are undernourished. Additionally, the prevalence for overweight or obesity in the adult population is 34.3% for males and 47.4% for females (FAO and SPC, 2020).

This archipelago has very few natural resources and belongs to the group of least developed countries in the world with over 80% of the population living in rural areas and about 91% of the population living within 5 kilometers (3.1 miles) of the coast (Food and Agriculture Organization of the United Nations, 2021; Solomon Islands, 2022; The World Bank, 2021; Food Security in Solomon Islands: - A Survey of Honiara Central Market, 2018). Therefore, the Solomon Islands is one of the most vulnerable countries to the impacts of climate change, ranking second of 181 countries in the WorldRiskIndex 2021 (Mucke et al., 2021).

In 2014, Tropical Cyclone Ita brought heavy rainfall and flash flooding to the Solomon Islands where it affected over 50,000 people, killing at least 20 people, damaging agriculture and infrastructure, and displacing food, health, water, and sanitation infrastructure (Solomon Islands: Worst Flooding in History, 2014). These climate extremes pose a major threat to food security in the Solomon Islands as agriculture sustains 85% of the country's rural economy and nearly 96% of rural households grow some of their own food.

While agricultural production throughout the Solomon Islands is known to be quite diverse due to the variations in climate, soil, and topography, the FAO reported a decline in traditional crop production

as a result of limitations to agricultural land and natural resources coupled with an increase in pests, diseases, and soil degradation (CGIAR, 2013; Food Security in Solomon Islands: - A Survey of Honiara Central Market, 2018). The increasing population creates major challenges for food security as the limited agricultural land hinders residents in urban areas from maintaining household gardens that rural communities rely on for their daily nutrition. The archipelago heavily relies on infrastructure and trucks to transport food throughout the islands, and extreme weather events such as flooding can disrupt the stability of the food system by halting access to food supply and food availability (The World Bank, 2021; Food Security in Solomon Islands: - A Survey of Honiara Central Market, 2018).

Tonga

The Tongan archipelago includes 176 islands of which 36 are inhabited, with over three-quarters of the 99,532 people living on the main island of Tongatapu. Tonga has a total land area of 21 sq km (8.1 square miles) with 43.1% of the land dedicated to agriculture. Although it has a tropical climate, temperatures are predicted to continue to rise leading to hotter days coupled with even less rainfall in the dry season from May to October and more rainfall in the wet season from November to April. Currently almost two-thirds of the annual rainfall comes during Tonga's wet season, and the amount of rain during these months is predicted to increase. Cyclone prevalence is anticipated to decrease although the intensity of storms is predicted to increase (Tonga Meteorological Service, and Pacific Climate Change Science Program, 2011).

Tonga has high exposure to natural hazards including volcanic eruptions, tsunamis, droughts, and cyclones and heavy rainfall that cause flooding and storm surges (Sattler et al., 2020). From the 1960s through 2011, there were five major tropical cyclones; a total that does not include 2018's Cyclone Gita, the strongest-ever recorded storm to hit the islands (Tonga, 2022). Recent events include the Niuatoputapu tsunami in 2009 and the Hunga Tonga-Hunga Ha'apai eruption in 2022, the latter of which caused tsunamis around the world (UNISDR and UNDP, 2012). Tonga consistently ranks high for its level of risk to disasters, and climate change is only anticipated to increase the frequency and intensity of weather events (World Risk Report 2014 - Institute for Environment and Human Security, 2014).

Tonga's overall GDP is US\$670 million with an annual per capita income of US\$4,625. Agriculture contributes nearly 20% to Tonga's GDP and the agriculture sector employs 19% of the total labor force. In 2014, Tonga imported 27.18% of its food and in 2013, exported 80.64% of its food. Over 22% of Tonga's population lives below the global basic needs poverty line. In 2019, less than 5% of the total population suffered from undernourishment or malnourishment while 23.29% of the population was suffering from moderate or severe levels of food insecurity (Food and Agriculture Organization of the United Nations, 2017).

Agriculture is the main economic activity, especially in rural areas where approximately 75% of the Tongan population resides. Unfortunately, the rural population is slowly declining, a loss that leads to labor shortages and negatively impacts access to food (El-Zabri, 2022). Although agriculture plays an important role in the Tongan economy, the agriculture sector was stagnant from 2005 through 2012 due to an "outmigration of the rural population, an aging farmer population, declining export opportunities, and the increasing frequency and impact of climate change-related extreme weather events" (Tonga

Agriculture Sector Plan [TASP], 2016, p. 1).

Tonga is ranked as having the third highest disaster risk out of 181 countries worldwide (Mucke et al., 2021). In response to damages caused by cyclones, Tonga created a Tonga Agriculture Sector Plan in 2015 emphasizing “promoting sustainable livelihoods and healthy foods by improving farmers’ knowledge and use of technologies for climate-resilient and diversified crops and livestock production systems, and the marketing of these products” as one of their focuses (Tonga Agriculture Sector Plan [TASP], 2016, p. 2). Other programs are also focused on crop diversification, especially indigenous and traditional foods that address both climate change and nutritional concerns (El-Zabri, 2022). One example includes the 14 remote communities on the island of ‘Eua who worked to develop risk-resilient livelihoods and food security practices, which included the involvement of local Heilala Vanilla company in the growing of vanilla as an export crop. Through their work TASP helped to create opportunities where farmers have access to systems of commercialization, higher-value markets, and knowledge of how to market their products.

Tuvalu

Tuvalu is a Polynesian micro-state with nine small coral islands. More than half of Tuvalu’s 10,679 people live on the main island of Funafuti (Tuvalu, 2022). Tuvalu is considered one of the smallest and most isolated countries with a total land area of 26 sq km (10 square miles), of which 60% is dedicated to agricultural use. Tuvalu has a tropical equatorial climate with consistent temperatures year-round and is often described as hot and humid. Tuvalu is subject to severe tropical storms and cyclones. Additionally, because of its low-lying islands, the fragile archipelago is extremely sensitive to sea level rise and is at acute risk to natural shocks and disasters (United Nations, 2021).

Tuvalu’s overall GDP is US\$50 million with an annual per capita income of US\$4,400. Despite the agriculture sector contributing 24.5% to overall GDP, Tuvalu exports a mere 3.22% of its food. On the other hand, Tuvalu imports 21.53% of its food, an indicator of heavy reliance on importation, especially as its domestic agricultural output is minimal and faces challenges such as limited access to agricultural land and poor quality of land such as soil that is shallow, acidic, and lacking in essential nutrients that are needed by plants (McCubbin et al., 2017; McGregor and Sheehy, 2019). Over 26% of the total population lives below the global basic needs poverty line and 51% suffered from undernourishment or malnutrition in 2019.

Climate extremes further impact the accessibility and availability of food throughout Tuvalu by directly affecting shipping and transportation infrastructure. Shipping schedules can become disrupted due to climate events. Additionally, ships carrying local and imported food may be unable to dock and unload due to strong winds and heavy rainfall (McCubbin et al., 2017). Once ships are able to dock, long transportation journeys from wharfs to domestic markets mean less fresh food and more canned foods as they will not spoil during transit (Reed, 2012).

Climate change and climate extremes continue to increase the likelihood of food insecurity throughout Tuvalu. For years, Tuvalu’s people watched as their crops and gardens were destroyed by climate extremes, increasing their reliance on importation. However, as part of its Food Futures Project, the Australian Government launched an innovative project aimed at establishing food gardens in small spaces in Tuvalu. The Foodcube is a raised, modular, water-efficient, wicking gardening system similar to

a raised gardening bed. The Foodcube allows Tuvalu residents to grow crops without the risk of saltwater intrusion and using only a fraction of the water used by traditional farming practices. This innovation of growing food is not only mobile, but it also has very little dependence on soil as the Foodcube can be filled with nutrient-rich compost.

Vanuatu

Vanuatu is made up of 85 islands, 65 of which are uninhabited, and 14 of which are home to most of the 301,295 citizens. With a total land area of 12,189 sq km (4,706 square miles), only 15.3% of the land is suitable for agricultural use. While Vanuatu has a tropical climate, it lies in both the ‘Ring of Fire,’ leading to frequent earthquakes and volcanic eruptions, and the Pacific Ocean’s cyclone belt, leading to frequent cyclones. Volcanic eruptions, cyclones, earthquakes, droughts, storm surges, and flooding are all a big part of Vanuatu’s history and continue to impact the country to the present day. In fact, a total of 124 cyclones have affected Vanuatu since 1939 and from 1969 to 2010, 94 cyclones passed within 400 kilometers (250 miles) of Port Vila, Vanuatu’s capital, and the number of storms each year has only continued to rise in recent years (UNISDR, UNDP, 2012).

These natural hazards have multifaceted repercussions for the people of Vanuatu who had an overall GDP of US\$850 million in 2019 and an annual per capita income in 2020 of US\$2,870 with 27.3% of GDP coming from agriculture in 2017. Over 60% of the workforce is employed by the agriculture sector, and agriculture plays an important role in providing food to the country’s citizens as well as food for export. Vanuatu imports 24.96% of its food and exports nearly 86% of its food. Over 15% of the population are living below the basic needs poverty line, and 9.30% of the population are suffering from undernourishment or malnutrition. From 2019 to 2020, 20.9% of the population experienced moderate levels of food insecurity and 2.4% experienced severe levels of food insecurity (Vanuatu Food Security Profile, 2019).

Vanuatu is prone to natural disasters and is consistently ranked as the world’s most at-risk country to natural hazards by the WorldRiskIndex (El-Zabri, 2022). With temperatures predicted to rise alongside more extreme rainfall and less frequent but more intense tropical cyclones, the island nation has no option but to respond to the changing climate (Vanuatu Meteorology and Geo-hazard Department & Pacific Climate Change Science Program, 2011). These climate extremes have detrimental impacts on Vanuatu’s food security given that three-quarters of Vanuatu’s population lives in rural areas and relies on small-scale agriculture to make a living. Agriculture and tourism, the main livelihoods of those living in rural areas, are often the sectors most impacted by disasters.

Communities have established Food Security Committees that have created Knowledge Hubs that work to combat drought, increase crop diversification, introduce new planting materials, and implement other climate change adaptation techniques in island farming communities. Vanuatu also created a Risk Resilient Unit that helped to establish a “community platform for sharing climate resilient crop varieties and farming techniques” to increase access at the community level (Vanuatu Country Brief for PRRP | UNDP in the Pacific, 2017, p. 2).

Analysis

Climate extremes and variability marked by events such as drought, flooding, intensive rainfall events, and storms including tropical cyclones have detrimental effects on the four pillars of food security and threaten food security throughout the ten Oceania countries studied in this report. Extreme drought conditions have a detrimental impact on agricultural and livestock productivity and create bottleneck effects to availability and accessibility that further exacerbate acute periods of food insecurity. These effects give rise to the heavy reliance on imported, nutrient-poor, high-calorie, processed food. On average, 31% of food products are imported into these countries.

This substantial reliance on food imports can also be attributed to migration to urban areas that results in dietary changes. Younger generations often see traditional foods as “tasteless” and “uninteresting,” an attitude that increases their family reliance on imported foods, which tend to have higher sugar and salt contents to which people are becoming more accustomed (Cauchi et al., 2019). Additionally, drought, flooding, landslides, and intensive rainfall can disrupt local food markets and lead to a rise in prices as a result of low yield, crop failure, and a loss of agricultural income on which an average of 60% of Oceania’s total workforce depends. These results have been found to disproportionately impact low-income consumers who are unable to access food sources due to price increases.

Apart from climate events and importation of food, a consistent, healthy water supply is integral to having a productive agriculture sector in order to both produce enough food to feed the population and produce for export in order to contribute to the country’s GDP. Unfortunately, contamination by naturally occurring chemicals and minerals, by local land use practices such as fertilizers or pesticides, and by salinization disrupts the already fragile water systems in most of these countries. These already-fragile water sources are highly vulnerable, and saltwater intrusion, infrastructure damage, and contamination can result in negative effects to water quantity and quality, thereby reducing the population’s ability to harvest safe drinking water and negatively affecting safe food preparation. Floods can significantly affect the production of crops by submerging them in contaminated water and degrading their fertility and yield, thereby reducing food supply and increasing the need to purchase unhealthy and expensive imported food.

Similarly, storms, including tropical cyclones, can destroy crops, damage agricultural and livestock infrastructure, and displace food, health, water, and sanitation systems. A loss of precious agricultural land due to storm-caused erosion, saltwater intrusion, and a general degradation of soil quality can lead to food shortages. Without the food needed to survive, those people living in more rural communities are forced to migrate to cities where a greater amount of the average diet comes from imported foods. The problem here lies in that, often, rural families do not have the purchasing power to pay for imported goods and, once in cities, they no longer have the agricultural land to grow their own food. Storm intensity is only predicted to increase in the 21st century in Oceania, a situation that will lead to a decrease in agricultural output while simultaneously damaging the infrastructure needed to increase the supply of imported foods. Aside from the effects of storms on individuals who live in affected areas, these disasters can also affect the country’s resources. Thus, it is important that the government of a country issues a state of emergency and requests international assistance (Rosegrant et al., 2015).

Countries within the Oceania region typically have poor soil conditions with low organic matter that already limits crop diversity. In order to grow a variety of crops and vegetables, soil must have high

organic matter and include nutrients such as nitrogen, potassium, and phosphorus. These countries not only have poor soil conditions, but they also experience an increase in soil erosion, which results in the loss of topsoil, soil compaction, and poor drainage, all of which cause shortfalls in plant reproduction and limit the accessibility and availability of food sources and supplies due to crop failure. Individuals are unable to consume or sell food they have grown, and they experience limits to the nutrition they consume and the income upon which they depend.

Food security is a major challenge in the Oceania region, yet throughout our research we learned that a food security index for the region does not exist. Based on the data we gathered, we conducted a coding analysis to identify the two countries at highest risk of climate change-induced food insecurity based on the country's percentage of population living below the basic needs poverty line, their ranking on the 2021 WorldRiskIndex, and their percentage of food importation. Based on our findings, we identified Tonga and Papua New Guinea as the two most at-risk countries whose food system stability will be most impacted by the effects of climate extremes.

Recommendations

The ten countries in Oceania, researched here, are experiencing food insecurity that has been exacerbated by extreme climate events. We are advocating that country specific disaster risk management plans include or continue to include an emphasis on tangible ways to address climate change-induced food insecurity. Given these countries' level of vulnerability, as identified by the 2021 WorldRiskIndex, we believe that disaster risk management and the overall management of food security should be considered interrelated and as equally important to the survival of the nations and as such, should be given equitable allocation of resources for development by these countries.

Strategic food security systems have the potential to significantly decrease food insecurity in these countries. Creating such systems to mitigate food insecurity under these circumstances will involve the use of many resources. To avoid exhausting resources, we are proposing that these countries consider implementing four policy recommendations in phases. The following four recommendations should be implemented in a manner that is most immediately beneficial to each country:

Increase educational awareness and opportunities for farmers to sustain their livelihood through the use of traditional food practices and climate-resilient crops.

This outreach can be done by building and developing the capacities of farmers through the introduction and use of traditional and modern farming technologies and practices, by providing resources to access climate resilient farming materials and crops, and by advancing opportunities to increase and diversify crops and livestock production.

Although it was not a typical climate event, food supply chains were disrupted during the COVID-19 pandemic, an event that highlighted the importance of local food production as a means to counterbalance reliance on imported food and increase food security (Provisioning During the COVID-19 Pandemic: How Rural Pacific Island Communities Maintained Food Security, 2022).

Communities that maintain traditional food practices of local farming and sharing food along family lines were more food secure during the pandemic whereas areas with cash-based economies often reported more food insecurity.

Working within communities to develop localized knowledge around best practices to ensure access to sustainable foods even in light of the impacts of climate extremes highlights the importance of working with the right people. Bottom-up methods play an important role in increasing traditional food practices and “the involvement of women in the communities has great impact since majority of work done in the gardens are by women” (Government of Vanuatu Quarterly Project Progress Report 3/2016 [October-December] Adaptation to Climate Change in the Coastal Zo, 2016, p. 17).

Invest in infrastructure including materials, supplies, and equipment that can aid and increase food production, sustain long-term food storage, and minimize food spoilage and waste.

Administrative actions and policy decisions that directly invest in materials and supplies to increase food storage and minimize food spoilage and waste will build resiliency in the food stability pillar to mitigate shortages and accessibility shortfalls after an extreme climate event. A good example of this is the World Bank-funded Samoa Agriculture and Fisheries Productivity and Marketing Project (SAFPROM). The components of this project target national institutions with programs to strengthen the management of resources by creating an enabling environment, strengthening performance of certain value-chains such as public good infrastructures, and diverting uncommitted resources to cover contingency emergency response (The World Bank, 2022).

Implement and promote incentives for farmers and citizens to support the local food production industry.

There can be success in the promotion of growing local and eating local as a way of limiting dependency on imported food and sustaining a strong food system. Governments can undertake this project through crop diversification and intercropping, also promoted as an additional source of income for families and households. The government can provide micro-grants for start-up capital, and farmers can diversify with vanilla and betel nuts and intercrop with sweet potato and taro since all of these need less land and labor, as shown by a project in West New Britain, PNG (Georgeou et al., 2022). This practice has the potential to limit dependency on unhealthy imported foods and increase earnings for farmers.

Similarly, the government can increase the awareness of the benefits of shopping and eating locally, through promotional campaigns on the benefits of indigenous and traditional foods, increasing awareness of healthy lifestyle and diets, educating the public on the cultural significance of local food items, and creating incentives to shop locally such as sales promotions on local food items.

Develop and build resiliency through public and private partnerships by expanding upon regional and international efforts to strengthen the food security pillars within the Pacific Region.

There is value in the continuation of the work being done to build food security resilience within the Pacific Region. Promotion of regional and international efforts to build resilience and finding solutions from within can be impactful in the fight against climate change and extreme climate events. We believe that this can be achieved through advocacy for expanding and developing local, regional, and global level capacities and knowledge through public-private partnerships. Additionally, investing in subject matter experts and institutional groups from within the region can add value. For example, researchers from the Pacific doing research within the Pacific can generate faster results since they are already knowledgeable regarding the problem. Organizations such as the Pacific Resilience Partnership are already established and have had some successes with “facilitating effective implementation of the framework for resilient development (FRDP) in the Pacific” are great models to follow (Pacific Resilience Partnership, 2022, para. 1).

Most Benefit to Proposed Recommendations

While all countries can benefit from implementing our proposed recommendations, our findings and analysis identified that Tonga and Papua New Guinea are the two countries most at-risk of climate change-induced food insecurity. Therefore, we can conclude that these two countries would most benefit from these recommendations.

Tonga and Papua New Guinea both rank in the top ten in the 2021 WorldRiskIndex, which assesses the disaster risk for 181 countries. On one hand, Tonga is ranked third and is classified as very high risk to exposure, at high risk due to susceptibility and lack of coping abilities, and at medium risk due to vulnerability and lack of adaptive capacities. On the other hand, Papua New Guinea is ranked ninth and is classified as high risk in all categories - i.e., exposure, vulnerability, susceptibility, lack of coping capacities, and lack of adaptive capacities.

The population that lives below the global basic needs poverty line in Tonga and Papua New Guinea is 22.50% and 39.90%, respectively. While Tonga has a lower percentage of its population living in poverty, they are more reliant on importation of food, importing over 27%. On the contrary, Papua New Guinea only imports 11.03% of its food. As we analyzed these two data points amongst the ten countries, we recognized that the data is over 13 years old, an element that may have changed our analysis if updated data was available. More updated research is needed to contribute to the growing body of knowledge to ensure data on these countries is regularly maintained.

By increasing educational awareness and opportunities for farmers to sustain their livelihoods, Tonga and Papua New Guinea would be able to establish sustainable farming practices with climate-resilient crops, a practice that would decrease their reliance on importation and increase the availability and accessibility of local, healthy, nutritious food options. By investing in infrastructure throughout these two countries, each would be able to provide food security for their communities with more food being available and accessible as post-harvest loss would be reduced with improved infrastructure quantity, quality, and practices. With sustainable farming practices and improved infrastructure, Tonga and Papua

New Guinea could implement and promote incentives for their communities to support local farmers and thereby build stronger local economies, create a sense of community, and improve the overall health and well-being of the community. Lastly, the implementation of these recommendations would help Tonga and Papua New Guinea to become more resilient and sustainable, and they can be used as a model to facilitate effective solutions for other countries experiencing climate change-induced food insecurity.

Conclusion

Food security is a fundamental right to which every human should have access. It means that they have the necessary food to nourish their bodies and live a healthy lifestyle. Unfortunately, nearly one in three people globally do not enjoy this right and lack reliable access to sufficient, secure, and nutritious food (FAO et al., 2021). Our research examined the impacts climate change has on food security within ten countries in the Oceania region. Within climate change phenomena, climate variability and climate extremes are among the most critical components that substantially impact food systems and food security within these countries.

Throughout our study, we gained a deeper understanding of the vulnerability of these ten countries to climate variability and climate extremes, specifically drought, flooding, and storms, and their impacts on the four food pillars (accessibility, availability, utilization, and stability of the food system). Climate extremes disrupt agricultural production and livestock rearing practices due to land degradation and scarcity of water supply, which result in reduced yields in livestock and agricultural productivity. Additionally, extreme weather events can damage critical infrastructure required to trade and transport food items to domestic and international markets. In turn, these climate extremes limit the availability of food items, hamper an individual's ability to access healthy and nutritious food options, and destabilize the food system. As a result, many individuals in these countries have a heavy reliance on imported goods and even the slightest disruption in the food supply chain can have a trickle-down effect on food security. While the COVID-19 pandemic is not directly climate related, it showed how vulnerable the food systems in these countries are to disruptions in the supply chain. The impacts caused by the COVID-19 pandemic coupled with existing food insecurity challenges will have had serious consequences for the overall health status of each country.

The main limitation of our research was the lack of available data, marked by insufficient, outdated, aggregated data and a lack of uniform information across these countries. Niue, Tuvalu, and Nauru, in particular, lacked updated information for multiple data points including the percentage of workers employed in the agriculture sector, the percentage of population suffering from undernourishment, and a ranking on the WorldRiskIndex. In order to have a better understanding of region-wide climate change impacts on food insecurity, data must be gathered on all countries, even those with limited land area and small populations. This limitation suggests the need for future studies including an in-depth analysis on each country to better assess and understand the scope and severity of food insecurity throughout the Oceania region. Despite this limitation, the authors believe that this research brings valuable contributions to the scholarship on food security within these ten Oceania countries.

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Appendices

Appendix A: Country Profiles

This appendix includes tables for the ten countries in the Oceania Region that were analyzed for this report. The tables include population statistics, physical characteristics, current economic status, climate characteristics, and statistics on food insecurity. We also analyze the four pillars of food security and impacts from climate extremes.

TABLE 01. FIJI OVERVIEW	
Population Statistics	
Total Population	898,402
Physical Characteristics	
Region	Melanesia
Number of Islands or Atolls	322 islands (only 110 are inhabited) and more than 500 islets
Total Land Area	18,274 sq km
% of Land Used for Agriculture	2,447m
Economy Characteristics	
GDP of Country	US\$9.86 billion (2020)
Per Capita Income	US\$5,058 (2020)
Agriculture's Contribution to GDP	13.5% (2017)
% of Food Imported	22.46% (2020)
% of Food Exported	60.02% (2019)
% of Labor Force Employed by Agriculture Sector	44.2% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical, marine
Natural Hazards	Cyclonic storms
Ranking for Global Disaster Risk from 2021 World Risk Index	#14
Food Insecurity	
% of Population Undernourished or Malnourished	5.60%
% of Population Living Below the Basic Needs Poverty Line	29.90%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	14.30%

TABLE 01. FIJI OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none">• Extreme drought conditions result in crop failure, which further limits access to food supplies and drives acute periods of food insecurity. Cyclone Winston (2016) destroyed crops and disrupted accessibility to food supplies.
Availability	<ul style="list-style-type: none">• Scarcity of safe freshwater due to shifts in seasons; long duration of droughts affected food availability, which then impacted health and livelihoods due to disruptions of agriculture and livestock productions.
Utilization	<ul style="list-style-type: none">• Reduced availability and inaccessibility of food due to persistent drought followed by prolonged nocturnal frosting in mountainous areas substantially undermines food sources, stocks, and supplies. This disruption trickled down to individual consumption levels and patterns where food utilization is disrupted.
Stability	<ul style="list-style-type: none">• Disruption of agricultural practices and livestock rearing hindered food availability, accessibility, and poor or improper (undernourishment) utilization of food. When these aspects of food are hampered, the overall food stability is disrupted and results in acute food insecurity.

TABLE 02. KIRIBATI OVERVIEW

Population Statistics	
Total Population	120,740
Physical Characteristics	
Region	Micronesia
Number of Islands or Atolls	33 islands (32 coral atoll islands, one raised limestone island); only 20 of the 33 islands are inhabited.
Total Land Area	811 sq km
% of Land Used for Agriculture	42% (2018) with extremely limited land availability to expand or shift agricultural area
Economy Characteristics	
GDP of Country	US\$270 million (2020)
Per Capita Income	US\$2,300 (2020)
Agriculture's Contribution to GDP	23% (2016)
% of Food Imported	43.69% (2020)
% of Food Exported	84.12% (2020)
% of Labor Force Employed by Agriculture Sector	15% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical; marine, hot, and humid, moderated by trade winds
Natural Hazards	Typhoons, occasional tornadoes, sea level rise
Ranking for Global Disaster Risk from 2021 World Risk Index	#19
Food Insecurity	
% of Population Undernourished or Malnourished	4.10% of people are undernourished. Adult obesity is a major health issue in Kiribati.
% of Population Living Below the Basic Needs Global Poverty Line	21.90%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	40.90%

TABLE 02. KIRIBATI OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none"> • Geographic vastness and remoteness of islands constrains access to food sources and availability of food due to infrastructure challenges and the high costs involved in transporting food. These challenges are exacerbated when infrastructure is damaged due to flooding and storms.
Availability	<ul style="list-style-type: none"> • Reduced livestock productivity due to heat stress. • Stress on water resources, water quality, and salinization damage to agricultural productivity and groundwater reserves due to flooding and heavy rainfall events. • An extended period of drought that occurred in 2016 depleted the country’s supply of freshwater, which resulted in a reduction in yields for agriculture crops and livestock systems. • Limited agricultural resources including poor soil fertility, uneven distribution of rainfall, lack of knowledge on agricultural practices, poor commitment to gardening, and the loss of traditional knowledge for traditional foods abandoned in favor of seasonal fruits/vegetables. • In 2004 and 2008, shipments failed to deliver essential food and led to a food crisis throughout the country.
Utilization	<ul style="list-style-type: none"> • The rapid decline in traditional foodways and replacement with the current diet, consisting of cheap, unhealthy, processed foods contributes to the importation of poor quality foods and micronutrient deficiencies and leads to impacts on the health and well-being of the Kiribati population. • Very poor infrastructure including a lack of roads, shipping facilities, cold storage facilities, physical market spaces, and safe transportation. Flooding and extreme rainfall events add a layer of vulnerability to already fragile roads and physical infrastructure. Poor infrastructure not only significantly limits the shelf life of food but also lowers quality. As a result of lower food quality, the Kiribati population lacks sufficient access to nutritious and healthy food options to maintain a healthy and optimal life. • The most recent drought (2016) affected quantity and quality of water for safe food preparation.
Stability	<ul style="list-style-type: none"> • Irregularities in shipments on top of already limited frequency of shipments to the country adds greater instability of the food system throughout the country.

TABLE 03. NAURU OVERVIEW

Population Statistics	
Total Population	11,832
Physical Characteristics	
Region	Micronesia
Number of Islands or Atolls	1 island
Total Land Area	21 sq km
% of Land Used for Agriculture	20% (2018)
Economy Characteristics	
GDP of Country	US\$150 million (2019)
Per Capita Income	US\$13,500 (2019)
Agriculture's Contribution to GDP	6.1% (2009)
% of Food Imported	90% (Accessed: April 2022)
% of Food Exported	-
% of Labor Force Employed by Agriculture Sector	Most of Nauru's labor force is employed within the public sector in education, administration, or transportation or within the mining industry
Climate Characteristics	
Climate Description	Tropical with monsoonal pattern
Natural Hazards	Droughts
Ranking for Global Disaster Risk from 2021 World Risk Index	Unranked (not included in the index due to too many missing values in the vulnerability indicators)
Food Insecurity	
% of Population Undernourished or Malnourished	-
% of Population Living Below the Basic Needs Global Poverty Line	-
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	-

TABLE 03. NARRU OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none"> Limited groundwater resources – including a lack of rivers and streams – due in part to the contamination from mining and poor waste management practices. These limited groundwater resources are at risk when climate extremes, such as flooding and extreme rainfall events, contaminate the water and drive vector-borne disease outbreaks. Food insecurity and nutrition shortfalls have been exacerbated by the COVID-19 pandemic when border closures disrupted the food supply chain and led to lack of food availability throughout the island.
Availability	<ul style="list-style-type: none"> Only 20% of the island is suitable for agricultural cultivation due to the impacts of phosphate mining that have limited yields in crop and livestock systems. With limited agricultural land, these issues are magnified when the country experiences climate extremes. Extreme rainfall events and rainfall delivered in short, high intensity events prohibit the ability to harvest water, damage water storage systems, and disrupt the ability to frequently replenish water.
Utilization	<ul style="list-style-type: none"> Heavily dependent on rainwater collection tanks and constantly at risk of being unable to meet water demands for drinking and safe food preparation. Water capture, storage, and treatment infrastructure is primarily located in the coastal zone and is at risk due to sea level rise, salinization, and contamination. These issues are exacerbated with the added layer of floods and intensive rainfall events. Fruits, vegetables, and other healthy, nutritious options tend to be more expensive; many Nauru citizens resort to poor quality, less expensive, and highly processed foods, which create a vulnerable population with a variety of health problems as they are unable to access and utilize any nutritious or healthy food options
Stability	<ul style="list-style-type: none"> Almost exclusively dependent on imported food products since the 1980s, Nauru suffers from the high cost of imported food, limited capacity for local food production, and limited purchasing power, and the stability of its food system and food security hang in a delicate balance.

TABLE 04. NIUE OVERVIEW

Population Statistics	
Total Population	1,549
Physical Characteristics	
Region	Polynesia
Number of Islands or Atolls	1 island (one raised atoll)
Total Land Area	260 sq km
% of Land Used for Agriculture	19.1% (2018)
Economy Characteristics	
GDP of Country	US\$10.01 million (2003)
Per Capita Income	US\$5,800 (2003)
Agriculture's Contribution to GDP	23.5% (2003)
% of Food Imported	-
% of Food Exported	-
% of Labor Force Employed by Agriculture Sector	85% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical; modified by southeast trade winds
Natural Hazards	Tropical cyclones
Ranking for Global Disaster Risk from 2021 World Risk Index	Unranked (not included in the index due to too many missing values in the vulnerability indicators)
Food Insecurity	
% of Population Undernourished or Malnourished	-
% of Population Living Below the Basic Needs Global Poverty Line	13%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	-

TABLE 04. NIUE OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none"> Climate extremes seriously affect the water management system on the island, creating devastating impacts to infrastructure development, which impairs food production, storage, and delivery systems.
Availability	<ul style="list-style-type: none"> Food availability and a diverse supply of food is impacted largely due to the poor soil conditions throughout the island. This condition affects production outcomes and the amount of planting stock. Additionally, the outdated irrigation system on the island and high input cost during periods of drought affect the output of agricultural production.
Utilization	<ul style="list-style-type: none"> Niue’s main staple is taro. Since the crop (taro) is not irrigated and the soils are thin, its roots begin to wither without water for two weeks, a condition regularly affecting 80% of Niue households that rely on taro as a main food item.
Stability	<ul style="list-style-type: none"> In an effort to stabilize food systems and to have an available supply of foods at all times, Niuean households supplement crop production with rearing livestock and cultivating poultry and eggs; however, this is not adequate. In 2013, 30% of the overall food imported into Niue was frozen chicken (Fukofuka, 2015). This demonstrates Niue’s level of dependency on the importation of food to supply its need.

TABLE 05. PAPUA NEW GUINEA OVERVIEW

Population Statistics	
Total Population	9,122,994
Physical Characteristics	
Region	Melanesia
Number of Islands or Atolls	600
Total Land Area	462,840 sq km
% of Land Used for Agriculture	2.6% (2018)
Economy Characteristics	
GDP of Country	US\$36.69 billion (2020)
Per Capita Income	US\$2,757 (2020)
Agriculture's Contribution to GDP	22.1% (2017)
% of Food Imported	11.03% (2012)
% of Food Exported	27.07% (2012)
% of Labor Force Employed by Agriculture Sector	85% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical, monsoonal pattern, seasonal temperature variation
Natural Hazards	Active volcanism, severe earthquakes, mudslides, tsunamis
Ranking for Global Disaster Risk from 2021 World Risk Index	#9
Food Insecurity	
% of Population Undernourished or Malnourished	24.6% (2018)
% of Population Living Below the Basic Needs Global Poverty Line	39.90%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	-

TABLE 05. PAPUA NEW GUINEA OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none">• Food supplies negatively impacted by continued droughts after frosts that prevent farmers from replanting crops.• Tropical Cyclone Ita destroyed infrastructure, displaced communities, and disrupted access to water and food supplies.
Availability	<ul style="list-style-type: none">• Local food markets were affected with doubling and tripling of food prices due to inaccessibility and shortages of food items, which hampered availability of food supplies.
Utilization	<ul style="list-style-type: none">• Inaccessibility and unavailability of food supplies due to disrupted deliveries and destruction of infrastructure by floods and storms, which not only affected food markets but also hampered overall food utilization.
Stability	<ul style="list-style-type: none">• Inland-coastal flooding and landslides due to sea level rise damage infrastructure and transportation networks, thereby destabilizing food supplies and leading to periods of acute food insecurity.

TABLE 06. SAMOA OVERVIEW

Population Statistics	
Total Population	199,853
Physical Characteristics	
Region	Polynesia
Number of Islands or Atolls	9 islands
Total Land Area	2,831 sq km
% of Land Used for Agriculture	12.4% (2018)
Economy Characteristics	
GDP of Country	US\$1.25 billion (2020)
Per Capita Income	US\$6,300 (2020)
Agriculture's Contribution to GDP	10.4% (2017)
% of Food Imported	25.47% (2019)
% of Food Exported	64.98% (2019)
% of Labor Force Employed by Agriculture Sector	65% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical
Natural Hazards	Occasional cyclones; active volcanism
Ranking for Global Disaster Risk from 2021 World Risk Index	#109
Food Insecurity	
% of Population Undernourished or Malnourished	4.60%
% of Population Living Below the Basic Needs Global Poverty Line	20.30%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	23.60%

TABLE 06. SAMOA OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none">Water induced vulnerabilities pose major barriers to accessing food on the island. Current extreme climate events mean the loss of quality and consistent yields in food production, resulting in a decrease in earnings, changes in markets, rising food prices, and supply chain infrastructure damage. This disruption has the potential to prevent households from accessing the quality and quantity of food supply that is needed.
Availability	<ul style="list-style-type: none">Samoa's fragile water system creates vulnerabilities in farming and food supply. Loss of crop production and significant delays to production are due to the lack of water. Additionally, the loss of productive land due to soil erosion prevents farming, and flood events cut farms off from water supply while heavy rains result in uncertain water quality and destroy crops; torrential rains impact inshore fishing; tropical cyclones cause extensive crop damage and long recovery times and create instability in the food supply.
Utilization	<ul style="list-style-type: none">Extreme weather events affect the availability of sufficient healthy food for households and create a reliance on imported foods that are high in calories and low in nutritional quality.
Stability	<ul style="list-style-type: none">Globalization, modern manufacturing practices, and open borders create competition for the agriculture sector and affect the volume of output while also impacting the labor market. Thus, when there is an extreme climate event, it becomes increasingly difficult to repair the damage to infrastructure at a pace that is needed to continue the production and supply of food and materials.

TABLE 07. THE SOLOMON ISLANDS OVERVIEW

Population Statistics	
Total Population	728,041
Physical Characteristics	
Region	Melanesia
Number of Islands or Atolls	6 major islands and over 900 smaller islands; only one-third of the islands are inhabited.
Total Land Area	28,230 sq km
% of Land Used for Agriculture	3.90% (2018)
Economy Characteristics	
GDP of Country	US\$1.71 billion (2020)
Per Capita Income	US\$2,500 (2020)
Agriculture's Contribution to GDP	34.3% (2017)
% of Food Imported	22.19% (2018)
% of Food Exported	20.15% (2018)
% of Labor Force Employed by Agriculture Sector	75% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical monsoon; few temperature and weather extremes
Natural Hazards	Geologically active region; exposed to intensive periods of rainfall, thunderstorms, extreme droughts, heatwaves, floods (coastal, fluvial, flash), king tides, earthquakes, tsunamis, volcanic activity, and tropical cyclones
Ranking for Global Disaster Risk from 2021 World Risk Index	#2
Food Insecurity	
% of Population Undernourished or Malnourished	16.50% (2019); 1 in 10 people are undernourished; malnutrition is a serious issue throughout the Solomon Islands.
% of Population Living Below the Basic Needs Global Poverty Line	12.70%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	-

TABLE 07. THE SOLOMON ISLANDS OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none">• In 2014, Tropical Cyclone Ita brought heavy rainfall and flash flooding to the Solomon Islands where it affected over 50,000 people, killed at least 20 people, damaged agricultural lands and infrastructure, and displaced food, health, water, and sanitation systems.• The productivity of small-scale agriculture is very important to the Solomon Islands' population as it allows them to maintain food security and household income.
Availability	<ul style="list-style-type: none">• Situated in a geologically active region with frequent climate extremes that have a major impact on agricultural production and food supply.• Decline in traditional crop production as a result of limitations of agricultural land and natural resources coupled with an increase in pests, diseases, and soil degradation.
Utilization	<ul style="list-style-type: none">• The increasing population creates major challenges for food security as the limited agricultural land keeps residents in urban areas from maintaining household gardens upon which rural communities rely for their daily nutrition.
Stability	<ul style="list-style-type: none">• Heavily reliant on infrastructure and trucks to transport food throughout the islands; extreme weather events such as flooding can disrupt the stability of the food system by halting access to food supply.

TABLE 08. TONGA OVERVIEW

Population Statistics	
Total Population	99,532
Physical Characteristics	
Region	Polynesia
Number of Islands or Atolls	176 (36 are inhabited)
Total Land Area	711 sq km
% of Land Used for Agriculture	43.1% (2018)
Economy Characteristics	
GDP of Country	US\$670 million (2019)
Per Capita Income	US\$4,625 (2020)
Agriculture's Contribution to GDP	19.9% (2017)
% of Food Imported	27.18% (2014)
% of Food Exported	80.64% (2013)**
% of Labor Force Employed by Agriculture Sector	19% (2019)*
Climate Characteristics	
Climate Description	Tropical
Natural Hazards	Cyclones, earthquakes, active volcanism
Ranking for Global Disaster Risk from 2021 World Risk Index	#3
Food Insecurity	
% of Population Undernourished or Malnourished	<5%
% of Population Living Below the Basic Needs Global Poverty Line	22.50% (2009)
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	23.29% (2019)

*For this data point, our information comes from The World Bank. The CIA World Factbook, which is the source for this data point in all other tables, shows the % of Population Employed by the Agriculture Sector as 2,006% (2006), which we believe is an error.

**For this data point, our information comes from the World Bank. However, the most recent statistic for importation showed 354.55% (2014), which we believe is an error. Thus, we used the next-to-last statistic from 2013.

TABLE 08. TONGA OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none"> • Tonga’s agriculture sector was stagnant from 2005 to 2012. With the vast majority of Tonga’s agriculture coming from traditional/ subsistence farming systems in rural parts of the country, these crops are particularly susceptible to extreme weather events. • Serious droughts in 1983, 1998, and 2006, heavy rains, major tropical cyclones, including Cyclone Gita in 2018, and seismic hazards, including the 2022 Hunga Tonga-Hunga Ha’apai eruption, all caused severe damage to crops, reducing yields and disrupting agricultural transportation infrastructure and leading to spikes in the cost of food. • Relying on very few export commodities, Tonga’s lack of crop diversification leaves its people susceptible to climate-induced food insecurity.
Availability	<ul style="list-style-type: none"> • As was demonstrated in the 2022 Hunga Tonga-Hunga Ha’apai volcanic eruption, Tonga is extremely vulnerable to disruptions of the transportation infrastructure that makes the import and export of agricultural products possible. This recent natural disaster caused an estimated US\$20.9 million in damages to infrastructure, and 85% of agricultural households across the nation were affected by the disaster.
Utilization	<ul style="list-style-type: none"> • Natural disasters such as cyclones often severely damage crops and force Tonga’s population to rely on imports, which are often nutrient-poor processed food as opposed to traditional whole foods such as yam, breadfruit, and cassava.
Stability	<ul style="list-style-type: none"> • Soil exhaustion is an issue in Tonga, due both to serious drought and other climate extremes and to an overreliance on a small range of crops rather than diversified crops that are also climate resilient.

TABLE 09. TUVALU OVERVIEW

Population Statistics	
Total Population	10,679
Physical Characteristics	
Region	Polynesia
Number of Islands or Atolls	Nine small coral islands
Total Land Area	26 sq km
% of Land Used for Agriculture	60% (2018)
Economy Characteristics	
GDP of Country	US\$50 million (2020)
Per Capita Income	US\$4,400 (2020)
Agriculture's Contribution to GDP	24.5% (2012)
% of Food Imported	21.53% (2008)
% of Food Exported	3.22% (2004)
% of Labor Force Employed by Agriculture Sector	Most people make a living from the exploitation of the sea and reefs. They also receive overseas remittances.
Climate Characteristics	
Climate Description	Tropical
Natural Hazards	Storms and cyclones
Ranking for Global Disaster Risk from 2021 World Risk Index	Unranked (not included in the index due to too many missing values in the vulnerability indicators)
Food Insecurity	
% of Population Undernourished or Malnourished	51.0%
% of Population Living Below the Basic Needs Global Poverty Line	26.30%
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	-

TABLE 09. TUVALU OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none">• Climate extremes impact access to food by directly affecting the shipping and/or transportation sector. Strong winds and heavy rains prevent ships carrying food from docking. Similarly, the shipping schedule is disrupted.
Availability	<ul style="list-style-type: none">• Soil salinity exacerbated by seawater infiltration prevents cultivation of a wide variety of plants and crops that can be grown and results in a limited supply of food.
Utilization	<ul style="list-style-type: none">• People are more reliant on imported foods, which are cheaper and less nutritious.
Stability	<ul style="list-style-type: none">• Strong winds and saltwater intrusion affect crops and prevent those who are living close to the ocean from gardening. Apart from affecting the availability of a consistent food supply, winds and saltwater also prevent farmers from earning income from agricultural production.

TABLE 10. VANUATU OVERVIEW

Population Statistics	
Total Population	301,295
Physical Characteristics	
Region	Melanesia
Number of Islands or Atolls	85 islands, 65 uninhabited
Total Land Area	12,189 sq km
% of Land Used for Agriculture	15.3% (2018)
Economy Characteristics	
GDP of Country	US\$850 million (2019)
Per Capita Income	US\$2,870 (2020)
Agriculture's Contribution to GDP	27.3% (2017)
% of Food Imported	24.96% (2011)
% of Food Exported	85.32% (2011)
% of Labor Force Employed by Agriculture Sector	65% (Accessed: April 2022)
Climate Characteristics	
Climate Description	Tropical
Natural Hazards	Tropical cyclones, active volcanism, earthquakes, tsunamis
Ranking for Global Disaster Risk from 2021 World Risk Index	#1
Food Insecurity	
% of Population Undernourished or Malnourished	9.30% (2019)
% of Population Living Below the Basic Needs Global Poverty Line	15.90% (2020)
% of Population Experiencing Moderate to Severe Levels of Food Insecurity from 2019	23.30% (2019)

TABLE 10. VANUATU OVERVIEW (cont.)

Food Pillars	Climate Extremes
Access	<ul style="list-style-type: none"> • With only a few commodity exports and 53% of the total dietary energy coming from foods purchased rather than grown, Vanuatu’s population is reliant on income from exports to pay for imported food. At the same time, these islands remain extremely vulnerable to natural disasters, and long distances between markets and rural communities leave these populations vulnerable to food shortages and price spikes that leave many unable to afford food. • The majority of Vanuatu’s population lives in rural communities, which often have poor soil and limited crop diversity and are often most impacted by disasters.
Availability	<ul style="list-style-type: none"> • Cyclone Pam in 2015 caused US\$360 million in losses, particularly affecting agricultural land by damaging trees and root crops and interrupting trade by damage done to infrastructure.
Utilization	<ul style="list-style-type: none"> • From 2014 to 2016, El Niño events caused drought events that left 40% of Vanuatu’s population experiencing water shortages. These water shortages threaten agriculture reliant on rainfall and increase incidence of disease.
Stability	<ul style="list-style-type: none"> • Agricultural livelihoods remain particularly vulnerable as Vanuatu increasingly experiences wetter wet seasons and dryer dry seasons and is forecast to experience more intense cyclones, which can lead to a volatile food market with price spikes that leave the country’s most vulnerable without the right conditions to grow food and unable to purchase nutritious food.

Appendix B: Country Statistics

This Appendix comprises three tables outlining the demographics of each country and statistics on poverty, undernourishment, and food insecurity (table and histogram). We also provide a table overview with the 2021 WorldRiskIndex ranking and which climate extremes each country is experiencing.

Demographics

Table 11 below provides an overview of each country's demographics. These 10 countries in Oceania together have 11.5 million people; Papua New Guinea has the largest population at 9,122,994 people, while Niue, Tuvalu, and Nauru have the smallest populations with 1,549, 10,679, and 11,832 people respectively. These ten countries have a combined GDP of US\$51.5 billion; Papua New Guinea has the largest GDP at US\$36.69 billion, and Niue has the smallest GDP at US\$10 million. The agriculture sectors account for 20.5% of the combined GDP at US\$46.5 billion, and, on average, more than 60% of each country's workforce is employed by the agriculture sector. Furthermore, average food import and export figures stand at 31.2% and 46.7% respectively.

TABLE 11. DEMOGRAPHICS						
Country	Population Size	Gdp Of Country (In Us\$)	Agriculture's Contribution To Gdp	% Of Labor Force Employed By Agricultural Sector	% Of Importation	% Of Exportation
Fiji	898,402	\$9.86 billion	13.5%	44.2%	22.46%	60.02%
Kiribati	120,740	\$270 million	23%	15%	43.69%	84.12%
Nauru	11,832	\$150 million	6.1%	-	90%	-
Niue	1,549	\$10.01 million	23.5%	-	-	-
Papua New Guinea	9,122,994	\$36.69 billion	22.1%	85%	11.03%	27.07%
Samoa	199,853	\$1.25 billion	10.4%	65%	25.47%	64.98%
Solomon Islands	728,041	\$1.71 billion	34.3%	75%	22.19%	20.15%
Tonga	99,532	\$670 million	19.9%	19%*	27.18%	80.64%**
Tuvalu	10,679	\$50 million	24.5%	-	21.53%	3.22%
Vanuatu	301,295	\$850 million	27.3%	65%	24.96%	85.32%

*For this data point, our information comes from The World Bank. The CIA World Factbook, which is the source for this data point in other tables, shows the % of Labor Force Employed by the Agriculture Sector as 2,006% (2006), which we believe is an error.

**For this data point, our information comes from The World Bank. However, the most recent statistic for importation showed 354.55% (2014), which we believe is an error. Thus, we used the next-to-last statistic from 2013.

Poverty, Undernourishment, and Food Insecurity

Table 12 and Figure 2 capture statistics on Poverty, Undernourishment, and Food Insecurity in each of the countries. The three factors captured on this table are all impacted at least partially by climate extremes. Climate extremes tend to increase the percentage of the population living below the global basic needs poverty line, the percentage of the population suffering from undernourishment, and the percentage of the population experiencing moderate to severe levels of food insecurity. These three factors also make it more difficult for a population to rebound after experiencing a climate extreme thus contributing to a vicious cycle of increased vulnerability and limited ability to rebound.

The global basic needs poverty line in 2018 for an individual was nearly US\$700 per year or US\$1.90 per day (The World Bank, 2022). As shown, the percentage of the population living below the global basic needs poverty line in the ten Oceania countries is relatively high and somewhat consistent throughout the region. In total, of the 11,494,917 people living in these ten Oceania countries, there are over 36% or 4.1 million people living below the global basic needs poverty line. Without the resources to meet basic needs, a population is unable to get the proper nourishment and may also suffer from food insecurity. There is variability within Oceania as a whole, but when considering malnourished people within Oceania, individuals are often forced to buy cheaper and consequently less nutritious food, especially during or following extreme events, a practice that increases malnutrition. Climate extremes often act as multipliers, increasingly impacting a population's most vulnerable, and in this case making it even harder for individuals to have access to a healthy, nutritious diet.

Note: Fields with a dash (-) indicate data was not available for 2019.

TABLE 12. POVERTY, UNDERNOURISHMENT, AND FOOD INSECURITY			
Country	% of Population Living Below Global Basic Needs Poverty Line	% of Population Suffering from Undernourishment in 2019	% of Population Experiencing Moderate to Severe Levels of Food Insecurity in 2019
Fiji	29.90% (2019)	5.60%	14.30%
Kiribati	21.90% (2020)	4.10%	40.90%
Nauru	-	-	-
Niue	13%	-	-
Papua New Guinea	39.90% (2009)	24.60%	-
Samoa	20.30% (2013)	4.60%	23.60%
Solomon Islands	12.70% (2012)	16.50%	-
Tonga	22.50% (2009)	-	23.29%
Tuvalu	26.30% (2010)	-	23.30%
Vanuatu	15.90% (2020)	9.30%	-

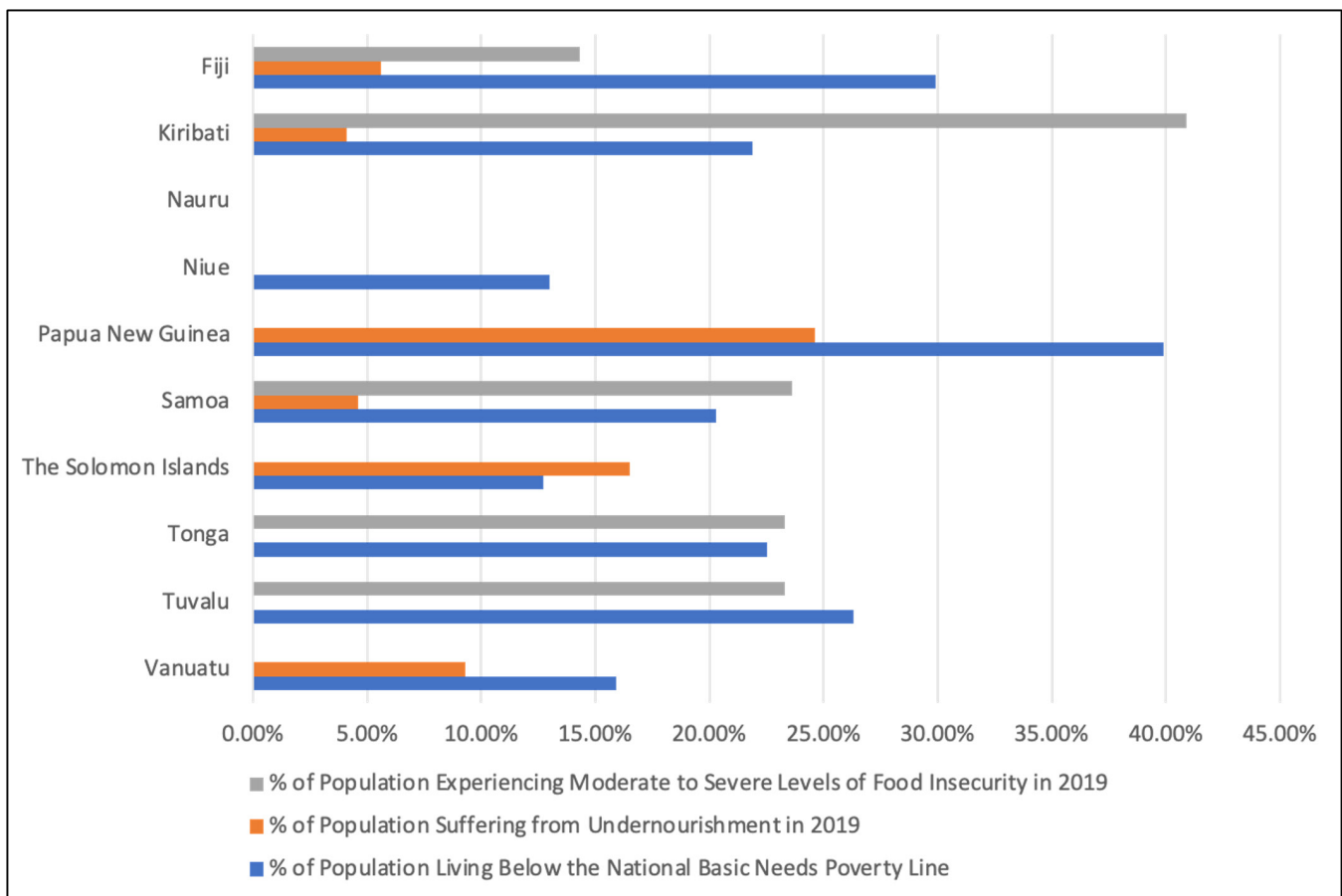


Figure 2. Poverty, Undernourishment, and Food Insecurity

WorldRiskIndex and Climate Extremes that Each Country Experiences

Table 13 captures data on the WorldRiskIndex ranking and climate extremes experienced in each country. The WorldRiskIndex, published annually since 2011 by a group of nine German development and relief organizations, ranks 181 countries worldwide; it considers a country’s exposure, vulnerability, susceptibility, lack of coping capacities, and lack of adaptive capacities in regard to hazards. In the 2021 WorldRiskIndex, Oceania ranked highest among all regions for vulnerability with Vanuatu ranked at number one with nine other island states ranking among the top 15 countries. Tonga (#3), Papua New Guinea (#9), and the Solomon Islands (#2) joined Vanuatu (#1) among the top ten countries. The WorldRiskIndex makes clear Oceania’s notorious distinction, with the exception of Australia and New Zealand, as a particularly disaster prone region and highlighting the ever present threat to these countries’ immediate and long term food security.

It is also worth noting that even though the report covers 99% of the world’s population, three countries within Oceania - Nauru, Niue, and Tuvalu - are without rankings due to a lack of information. This points to an important finding that although these populations are relatively small, they are situated in an extremely vulnerable part of the planet, and additional research is needed to prepare for and combat climate-induced extreme weather events and their impacts on the food security in these small island countries. Specifically, drought, flooding (heavy rainfall, river flooding, coastal erosion, and landslides), and storms (tropical cyclones and aftermath effects, and storm surges), among many others, are the most significant and common climate extremes that the ten Oceania countries experience.

TABLE 13. WORLDRIKINDEX 2021 RANKING,CLIMATE EXTREMES EACH COUNTRY IS EXPERIENCING

Country	WorldRiskIndex 2021	Drought	Flooding	Storms
Fiji	#14	Yes	Yes	Yes
Kiribati	#19	Yes	Yes	Yes
Nauru	Unranked, not included in the index due to too many missing values in the vulnerability indicators.	Yes	Yes	Yes
Niue	Unranked, not included in the index due to too many missing values in the vulnerability indicators.	Yes	Yes	Yes
Papua New Guinea	#9	Yes	Yes	Yes
Samoa	#109	Yes	Yes	Yes
Solomon Islands	#2	Yes	Yes	Yes
Tonga	#3	Yes	Yes	Yes
Tuvalu	Unranked, not included in the index due to too many missing values in the vulnerability indicators.	Yes	Yes	Yes
Vanuatu	#1	Yes	Yes	Yes



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