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The Adverse Impact of Pervasive Flooding on Guyana's Food Supply

Guyana is a small South American country with significant flooding issues that contribute directly to the insecurity of its food supply. One major hindrance to attaining food security is its infrastructure, particularly its flood management. Eighty to ninety percent of Guyana's population reside in low-lying areas below sea level and are the most affected by floods due to their geographic location (Guyana Population 1950-2022). These areas are purported to be protected by Guyana's coastal defense system called the seawall but this system is antiquated and in dire need of repair and modernization. Guyana's drainage infrastructure is very situational in some ways and underperforming in others. With extreme floods that affect agriculture and people, along with underperforming infrastructure, it's a recipe for disaster. Furthermore, with the worsening effects of climate change, Guyana needs to be able to adapt to the already existing and future problems the country may have regarding its drainage infrastructure. This research paper analyzes this ongoing problem and explores further viable solutions to combat flooding and by extension, acquiring food security.

Guyana has a small population of about 794,045 people currently (Guyana Population 1950-2022). Of these people, 26.97% live in urban areas, and 73.21% live in rural areas (Guyana - Urban Population (% of Total) 2022 Data 2023 Forecast 1960-2020 Historical). The country is a unitary multiparty republic with one legislative house called the National Assembly. Their current prime minister is Mark Phillips, who was elected as Guyana's 9th prime minister in August of 2020. The current president is Mohamed Irfaan Ali, who was elected on March 2nd, 2022. Guyana's current constitution was put into effect on October 6, 1980 (Richardson, Bonham C, and Jack K Menke).

There is about 6.36% of cultivated land in Guyana (Guyana - Agricultural Land (% of Land Area) 2022 Data 2023 Forecast 1961-2018 Historical). Major food crops include cassava, corn, bananas, assorted vegetables, and various citrus fruits. Main cash crops include sugarcane and rice primarily but other secondary cash crops include coffee and cacao. Rice and sugarcane are raised and harvested via both mechanization and manual labor. General livestock raised in Guyana typically includes beef and dairy cattle, pigs, goats, sheep, and fowl/poultry (Richardson, Bonham C, and Jack K Menke). An average farm in Guyana is about 10 acres. The climate there consists of high temperatures, heavy rainfall with small seasonal differences, high humidity, and high average cloud cover. With rainfall in Guyana, "the annual average at Georgetown, Guyana is about 90 inches, and on the interior Rupununi Savannah, it is about 70 inches. The "long wet season, April to August, and a short wet season, from December to early February" are Guyana's seasons (Climate of Guyana). The climate has been relatively stable until recently.

Guyana is roughly 80% forest (Richardson, Bonham C, and Jack K Menke). It has about 215,000 square kilometers to its name and is the 3rd smallest nation in South America (WorldAtlas). In fact, Guyana's total land area is just under that of Idaho (Richardson, Bonham C, and Jack K Menke). The coastal areas of Guyana "sit from 19.7 inches (0.5 meters) to 39.4 inches (1 meter) below sea level (Flooding of the Coastal Region, Guyana: Global Warming Effects)."

The typical family size in Guyana is about 3.7 people per household (Average Household Size in Guyana). Most homes in Guyana are constructed from either wood or cement and only have 2-3 rooms (Living Conditions). Typically, a family's diet will consist of rice, wheat, plantain, cassava, and also much fewer amounts of meat and fresh vegetables as seen in countries like the United States. Since Guyana is so ethnically diverse, there tend to be slight differences in diet from home to home because of this (Nutritional Guidelines For Guyana's Agricultural Plan). Families mostly get their food from local

markets and imports but few grow their food. They usually cook their food in home kitchens, usually with a stove or a fireside (also known as a clay oven) (Food and Nutrition Security Strategy for Guyana). Families in Guyana also have affordable access to both healthcare and education although the quality is not of a first-world country (Guyana Healthcare System & Insurance Options for Expats) (Education System in Guyana). Regarding living conditions, not all families have access to clean water and indoor plumbing. Some families also have access to telephones and local markets, and almost all families have access to basic roads (Living Conditions). The main barriers that families face include but are not limited to, poverty, ethnically-based political tensions, and lack of getting higher education due to having to work full-time to survive (Top 10 Facts about Living Conditions in Guyana).

Infrastructure within Guyana is in no way close to meeting the needs of the country. More specifically their drainage/irrigation systems aren't performing well. In fact, in one flood alone about 90% of Guyana's crops and livestock and over 6,900 households were destroyed and severely affected, respectively, by flood and irrigation problems. This isn't a one-in-a-lifetime occurrence either, large floods happen frequently in Guyana. This trend is worsening with a drastic increase in rainfall and the worsening of their drainage infrastructure (Close to 90 Percent of Nation's Crops, Livestock Destroyed by Floods-Agri. Minister) (Levenson, Michael). The problem is mainly their 140-year-old coastal sea defense & drainage system is in a state of disrepair. Their coastal sea defense is used to keep the ocean out since Guyana's coast is significantly below sea level (*Water Resources Assessment of Guyana*). Their infrastructure failures affect all people, especially children who are affected by the contaminated water and further impact their food security in an already poverty-stricken country (*Children's Health and Safety a Priority as Guyana Experiences Its Worst Moment*). Sometimes indigenous populations are as or even more affected compared to the general population. Some of these areas would include places such as Kwakwani, which was declared in much more severe condition than other areas. These failures to efficiently deal with floods lead to them affecting Guyana in a multitude of ways especially Guyana's food supply and security, education, social services, and medical services.

Guyana is in a losing battle with climate change and rising tides. In 2019, in the Guyanese village of Mahaicony farmers were hit by flooding due to an unexpected, significantly high spring tide which battered and overtopped "the crumbling sea defense that protected the agriculture and residential lands (Papannah, David)." The inability to predict such drastic rising tides deters efforts to stop large waves from breaching the country's sea walls and flooding both residential and farming lands. According to a recent report by Guyana's governmental Office of Climate Change, "in November-February and June-July within the last five years (2015-2020), the spring tides were higher than average (Papannah, David)." In fact, in November of 2019, one of the highest ever recorded tides saw waves as high as 3.29 meters above Guyana's sea defense. Over 35 livestock and crop farmers, in 2020, had their lands flooded killing their plants/animals, and for crop farmers the intrusive saltwater caused salinization of their soil, making it impossible for them to grow future crops, and as a result, these farmers have been displaced. Due to the losses from the flooding, the displacement and loss of useful land have caused enormous economic strife in dozens of farmers' lives. Many of them have trouble finding jobs due to the fact that farming is all they know, especially with many of their main investments being livestock/crops and farmland which is now all redundant (Papannah, David).

"While Guyanese people used to experience two wet periods in May-June and December-January, this has now changed. The South American country is now recording periods of intense rainfall as well as prolonged dry seasons (Papannah, David)." This combination of drastically rising tides, intense rainfall, and the extensive dry season is a deadly mix for disaster. Due to the hydrophobic nature of very dry soil, this could lead to floods lasting longer and even a build-up in floods as more flooding could occur as existing floods are still around. And with rising tides and increasingly intense rainfall, this could mean even more frequent flooding and potentially an increase in the severity of floods. Rising sea levels have

also led to land loss and the destruction of the mangrove forests that act as a barrier against powerful waves.

Past solutions used, for example, were drainage pumps which are designed to help lower floods caused by rainfall. These pumps only remove about 2-3 inches of water within 24hrs (Dhamramdial, Ram, and Vishnu Bisram). Not only are they unable to perform but they are expensive and take a long time to install. The main strength of the pumps was that they do remove some rainwater, to some extent. Another solution that has been used is called a drainage basin, more specifically Liliendaal and Ogle drainage basins. Currently, they only handle lower amounts of water and are limited due to size and capacity. But they can handle moderate amounts of rainfall (especially in low-lying areas where water tends to congregate) (*Strengthening Guyana's Ability to Manage Flood Risk in the East Demerara Coastal Area*).

Another solution that is in the works is strengthening flood forecasting/early warning systems and capacity-building activities. Their strengths would include: evacuating potentially impacted areas, planning for floods, and ensuring infrastructure is in good condition before flooding. However, there would be a lack of communication to warn poorer/rural areas. The dispersed people in rural areas would be very difficult to reach for evacuation (*Strengthening Guyana's Ability to Manage Flood Risk in the East Demerara Coastal Area*).

And the last solution currently in use is the use of a coastal levee or seawall. Seawalls keep out the ocean while being able to open to let out floodwaters. The seawalls are gravity fed to drain but they can only work depending on the sea level. According to UN Climate Technology Centre & Network, seawalls “The main advantage of a seawall is that it provides a high degree of protection against coastal flooding and erosion. A well-maintained and appropriately designed seawall will also fix the boundary between the sea and land to ensure no further erosion will occur – this is beneficial if the shoreline is home to important infrastructure or other buildings of importance. As well as fixing the boundary between land and sea, seawalls also provide coastal flood protection against extreme water levels (Linham, Matthew M, and Robert J Nicholls).” Sea walls are overall better than other types of coastal defense systems, especially if vertical coastal sea walls are selected (Linham, Matthew M, and Robert J Nicholls). Due to the elevation difference between Guyana’s coast and the ocean, the ocean must be at low tide for the floodwaters to be able to flow out (Flooding of the Coastal Region, Guyana: Global Warming Effects). There is also continuous erosion of the seawalls. However, to some extent, it does help to protect crops, livestock, & other infrastructure, but the process is more delayed than it needs to be. However, it is currently the best solution Guyana has against flooding.

I propose to fortify the seawalls and install pumps along with the already existing gravity-fed gates (sluice gates). Firstly, there would be inspections of the most high-priority seawalls and fortify those most needed to combat the erosion taking place. For the most prioritized seawalls, I would strategically install drainage pumps with backup generators, to improve functionality and reliability, in addition to the gravity-fed sluice gates. This solution would have the potential to provide relief for about 80% of Guyana’s population (Flooding of the Coastal Region, Guyana: Global Warming Effects). Also, if properly designed, the improved sea walls with increased security could maintain hinterland values and can promote investment and development in areas near the coast. Additionally, if well designed these seawalls would have a “high amenity value - in many countries, seawalls incorporate promenades which encourage recreation and tourism (Linham, Matthew M, and Robert J Nicholls).” Ideally, the local Guyana government would seek expertise from the US Army Corp. of Engineers due to their past work with the seawalls in Louisiana for Hurricane Katrina.

Guyana has received a total of 85 million euros from the European Union’s developmental aid to develop Guyana’s sea defense systems since the 1970s and an additional 7.9 million euros in 2020, which they can

use for the development of this important project (Papannah, David). In addition, recent discoveries of large oil reserves offshore in Guyana have attracted many oil extracting companies who have an interest in Guyana's stability and therefore infrastructure. As a part of the drilling rights, possibly Guyana can request that these companies invest in fortifying and improving the sea walls as part of their contract. Alternatively, Guyana's government should leverage some of its new oil revenue to develop its infrastructure, especially flood protection. However, if the funds fall short, Guyana's government would ideally take out loans from the World Bank and the United Nations to be able to fully fund this project.

When thinking about the cost of upgrading Guyana's sea walls we must think of many different factors that can affect the pricing of this important project. Given the trend of more frequent intense tidal surges, raising the height of sea walls in Guyana is critical. The design height of the sea walls must be taken into consideration as this can account for the number and size of materials needed for construction and can help in estimating the average project build time. Average waves surrounding the sea walls can affect costs as well. "Deeper waters and exposed coasts cause higher wave loadings which will mean the structure must be more robust, thus higher costs (Linham, Matthew M, and Robert J Nicholls)." There is also the matter of deciding on single or multi-stage construction of the sea walls (single being more expensive), while they wouldn't have to build new sea walls but rather upgrade the existing sea walls, different stages of construction are still significant to this project's cost (Linham, Matthew M, and Robert J Nicholls). The types of construction materials used in this project are essential and are another very significant factor in calculating the overall project cost, especially when taking into account the potential scarcity of some construction materials like when thinking about the general availability and location relative to this project. We must also think of the availability and general cost of human resources. But while considering this, we have the opportunity to create jobs and potentially improve the economy. Not just by the physical rebuilding and upgrading of the sea walls but Guyana's government could also let these same people keep their jobs once the renovation is completed in order to serve in the maintenance of this newly completed coastal defense system.

There must be a collaborative effort where local communities play a major role in assisting and maintaining this infrastructure. For this project to be successful, Guyana's government would have to enact an emergency disaster management organization. This organization will most commonly have to be the most proactive against rusting, sea wall degradation, and adaptation to climate change. When utilizing sea walls, it is possible to update these structures by significantly increasing the sea wall height to protect against sea level rise throughout the years. However, upgrading a sea wall for sea level rise will leave behind a weakened section called a 'construction joint,' which is a section in between the newly built part of a seawall of the old part of the sea wall. The organization must be able to effectively reinforce and maintain this construction joint (Linham, Matthew M, and Robert J Nicholls). Maintenance costs of sea walls have the potential to increase. They can increase due to the projected rise in sea level and when a difficult sea wall design has been selected to use. While enacting my plan, we would have to be conscious of religious areas and respect local cultural norms, such as the commissioning process for new equipment and infrastructure may include attending social events. In order for this project to be sustainable, the Emergency Disaster Management Organization with adequate government funding, via taxation, should continuously maintain and improve the installed infrastructure. Continuous adequate funding is required as even the UN Climate Technology Centre & Network suggests, "These costs are ongoing for the life of the structure and are therefore likely to result in significant levels of investment through a project's lifetime. Continued investment in maintenance is highly recommended to ensure defenses continue to provide design levels of protection (Linham, Matthew M, and Robert J Nicholls)."

Based on the analysis and research, the proposed solution can be very effective in combating Guyana's flooding dilemma and directly impacting its food security in the future. From drowning livestock to plants dying and soil losing the ability to be planted again, Guyana is steadily losing its economy and more importantly, its national food security. Additionally, with 80-90% of the country living in the

coastal zone, which is significantly below sea level, Guyana needs to take action effectively and quickly before harsher repercussions occur due to its inability to be proactive. On a personal note, my parents and grandparents immigrated from Guyana almost 40 years ago, but still hold close ties to the country. Being able to be part of the recommendation and potential execution of such a project would give me and my family great pride and personal satisfaction. If Guyana as a whole, fails to reinforce its seawalls or provide a more efficient solution to flooding and its damages, and maintain these changes, the country is doomed to a never-ending cycle of hardship and lost potential.

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