Analysing The Effects of Rising Sea Levels on Developing Nations and Examining Emerging Solutions

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Abstract

This paper will highlight the challenges that rising sea levels pose for developing countries such as the Maldives and Kiribati, including safety measures being put in place to prevent climate disasters. Due to land-based glacial melting, thermal expansion caused by warming of the oceans and a variety of other factors, global sea levels are continuing to rise. Island nations and developing countries are being hit the hardest, with some employing solutions that work. This paper will analyse solutions already in place including sills, elevated roads and coastal security strategies, along with the political systems put in place by different countries that are most vulnerable. It will also look at future solutions that are being engineered by certain cities and how they could be adapted to other developing cities with less resources.

1 Introduction

With rapid changes in the climate causing many problems for countries around the world, rising sea levels are among the most pressing. Island nations are facing the threat of sinking or being wiped out. Even some of the most developed cities in the world are not immune to the threat of sea level rise. It is estimated that there will be a three feet sea level rise by 2050 [Wan21]. Although this does not sound like a lot, many countries that are already at risk of sinking land and infrastructure, a few feet could transform lives. There are solutions being engineered, but this is an issue that more people must be aware of. This paper will specifically focus on how climate resilient infrastructure can be built and implemented in countries that are most at risk for sea level rise. It will also discuss the factors that are preventing a developing country from adopting climate resilient technologies. There will be a focus on island nations such as Kiribati and the Maldives, both affected by climate change induced natural

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disasters and rising sea levels. It will explore the past solutions that have already been implemented as well as future solutions that can improve the quality of life of citizens and infrastructure. For example, the Maldives was one of the first countries to take action in terms of sea level rise and built a wall after a major flood, decreasing their impact on the population. This type of wall or the dikes built in the Netherlands can be implemented in developing countries that are most vulnerable. There will also be a comparative analysis on the different technologies being adapted by developing and developed countries, as a way to determine how governmental and economic factors play a role in addressing the threat of climate change and rising sea levels. It will look at the everyday lives of the most vulnerable populations who are most at risk of losing resources to climate change induced natural disasters like flooding and sea level rise.

When looking at climate resilient infrastructure that can withstand the effects of sea level rise and other natural disasters, it is important to focus on past solutions that have already been implemented to see what works effectively and what does not. In the past, island nations such as the Maldives have adapted walls to limit the effects of flooding and protect ecosystems from rising sea levels. These types of walls can be found today, as one third of the U.S coastline is protected by walls that prevent floods [BC17] . Although this type of system worked during the 1987 floods in Maldives, it is not a feasible long term solution. A better solution would be to use mineral based shorelines that are water absorbent and will not disturb the natural ecosystems of the water [BC17] . Another solution that will be discussed in the paper is sediment based protection in the form of beach and shore nourishment and dunes [ea19]. This along with retreating from the coast or making people move away from coastal regions and further inland are responses to the issue of sea level rise. The effectiveness of the different types of protection including new solutions that are being engineered and mitigation techniques will be analysed to see what types of cities around the world can benefit from them. The drawbacks and disadvantages to certain solutions will also be looked at, as there are many factors preventing cities from adapting these solutions. For example, political and governance factors such as a lack of government funding for environmental initiatives and an increase in denial by the general population prevent a country from achieving its sustainability standard. For example, the Caribbean country of Haiti has faced many natural disasters over the years caused by climate change, yet only 0.4 percent of its land is protected by the government [EK19]. This coupled with the country's low GDP per capita and high poverty rate is preventing the country from addressing the issues, which includes rising sea levels. Many countries in Africa are experiencing the same fate, as their low GDP and high levels of government corruption is preventing the general population from raising awareness about climate induced natural disasters. This paper will look further at the factors preventing a country from reaching its sustainability goals and decreasing the rise of sea levels, and the innovative solutions that are able to combat it.

Through analyzing the situation of different countries including their government policies, vulnerability to climate change induced disasters and the solutions being put in place, a conclusion can be reached on the optimal solutions that

can best reverse the harmful effects of sea level rise. First, information will be provided on what problems developed cities around the world are facing such as those in Florida and Hawaii, then the solutions that are being implemented will be discussed. Other solutions that are similar will be analysed but in terms of developing cities in order to determine what economic and governmental barriers are preventing a country from reducing the negative effects caused by sea level rise. After those factors are determined, a conclusion can be reached on whether or not it would be feasible for those developing nations to adopt engineering technologies found in developed nations. The data being analysed and the conclusion being reached can aid vulnerable countries that are most at risk for sea level rise and help create feasible solutions that can work in the long term, as well as climate resilient infrastructure that can withstand other natural disasters.

2 Rising Sea Levels and Climate Change

As a result of anthropogenic changes in the earth's climate, the global sea level is rising, which causes implications for coastal communities, low lying cities and island nations. Scientists are estimating that sea levels are going to rise by at least 20 feet by the next 100 to 200 years [Wan21]. This affects many of the world's population living in coastal communities, as rising sea levels threaten infrastructure related to livable spaces, industries and so much more. The cause of these sea level rises and other natural disasters is global warming, as increased temperatures are causing glaciers and ice sheets to melt which causes the volume of water in oceans and large bodies of water to increase. As global warming causes water to warm, the volume of that water is also increasing. Due to an increase in glacial melting over the course of the century, global sea level rise has increased by double [Wan21]. Calving, which is the process of breaking off icebergs and sheets of ice, depends on a variety of factors including the temperature of water, internal strength of ice and interaction with ocean waves and tides [ea19]. According to the IPCC report, the rate at which these ice sheets are melting is difficult to model, but scientists are gaining a better understanding of it. Nevertheless, major ice sheets like the Antarctic Ice Sheet (AIS) and Greenland Ice Sheet (GIS) are declining at rapid levels. Scientists estimate that glacial melting has contributed to nearly 20 percent of sea level rise since 2000. Reducing greenhouse gas emissions, especially those provided by CO2, can decrease rising sea levels induced by global warming. Government mandates of fossil fuel uses and other policies intended to reduce global warming have also been successful in many countries. In order to reduce the pace at which global sea levels are rising, it is crucial to first acknowledge the anthropogenic changes to climate that have caused them to rise.

3 Global Vulnerability to Sea Level Rise

It was previously discussed that those most affected by rising sea levels are island nations, coastal communities and low lying cities. Recently, scientists discovered that new data estimates triple the amount of people who will be affected by rising sea levels [SAK19]. Using CoastalDEM and SRTM data, scientists were able to predict the number of people on land that will be affected by coastal inundation with considerations for future migration and development patterns. Locations studied include the Pearl River Delta, China, Bangladesh, Jakarta, Indonesia and Bangkok, Thailand. It is estimated that a global total of 110 million people are currently living below the high tide line [SAK19]. The high tide line refers to the highest point of land reached during spring tide. People living in these areas are at risk for infrastructure loss during high tide and at greater risk for natural disasters like coastal flooding. In 19 countries outside of Asia, CoastalDEM estimates that 10 percent or more of their populations will fall below high tide, increasing their vulnerability [SAK19]. In terms of the study conducted by Nature, it was found that CoastalDEM has a lower margin of error compared to STRM as well as other global DEM's. This makes the study a reliable source for data on elevation and sea level rise in various countries. Previous studies in recent years estimated the number of people at risk for global sea level rise around the world to only be at 80 million. Luckily, cutting climate pollution can improve these effects and result in better outcomes [Sha19]. The worst case scenario is 9 percent of the world's population facing floods in the year 2100, but if carbon emissions are sharply cut, that number can be reduced to half [Sha19]. Looking further into the countries that were studied in the Nature paper, Bangladesh is cited as one of the most vulnerable countries to climate change and accelerated sea level rise. More than 13 million people will be displaced by the inundation without considering the rapid population growth. The Sundarbans in Bangladesh is the second largest mangrove swamp in the world and home to endangered species such as the bengal tiger and source for agricultural land [Lea20]. With a 1 meter rise in sea levels, this swamp would be lost along with the agricultural land used to grow crops such as rice. Considering the poverty rate of Bangladesh, it would be difficult for them to adapt to such changes. Due to the country's heavy reliance on rice for food and local farming for jobs, loss of mangrove swamps and land would have devastating consequences on the economy and living conditions of people. Other countries with long coastlines like China are also impacted, especially its offshore islands. Current solutions being put in place include dikes which combat coastal flooding and relative sea level rise.

3.1 Vulnerability of Developing Populations

Developing countries are most at risk when it comes to global sea level rise, as they often have the least amount of resources to fight against these climate induced natural disasters. A clear example of this can be seen in Haiti, as the numerous earthquakes and natural disasters have devastated the country over

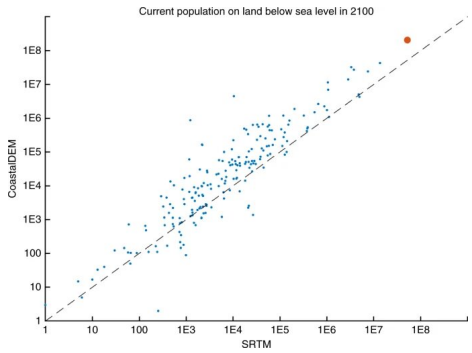

Figure 1: CoastalDEM data from [SAK19]

the past few years. Due to its high poverty rate, the country requires humanitarian aid from different countries when disaster strikes. In the 2010 Haiti earthquake, an estimated 7.5-8.5 billion USD was lost in areas encompassing Haiti and the Dominican Republic. Yet the Dominican Republic was not hit as hard in terms of instability because of the differences in government and poverty rates. Haiti ranks 170 on the Human Development Index out of 189 countries, which makes it among the poorest in the world. Much of the poverty seen in Haiti can be attributed to the corrupt government and poor public policies such as lack of infrastructure, roads, social services and healthcare systems. These are all systems that help a country prosper and remain resilient. Due to the location of Haiti, being at the intersection of two tectonic plates, it is more vulnerable to natural disasters such as earthquakes. Although the location of a country is not a factor that can be controlled, government response and public policy is something that can be changed. After Hurricane Matthew struck, Haiti received international financial aid directed at controlling the damage to citizens and infrastructure. Yet this community spends less than 0.5 percent of that money on mitigating the risks posed by these hazards [Wan21]. A solution to this issue would be if the government spent more money trying to make resilient communities and infrastructure that can withstand the devastation caused by natural disasters. Current solutions being put in place to combat natural disasters such as earthquakes and hurricanes can be seen in countries like the United States. For example, Florida is much like Haiti as it is also prone to natural disasters such as hurricanes and floods due to its location. Since it's very close to sea level, it is extremely susceptible to floods and other natural disasters that have similar devastating effects. Although unlike Haiti, Florida has better resources put in place to manage these issues. There are government policies and incentives put in place to protect endangered ecosystems such as the coral reefs near Florida's coast [Urr17]. There are also social services and good urban planning that allows Florida residents to cope with the damages caused by flooding and hurricanes. Right now, there are options for people living in Florida to elevate their houses using wooden stilts or concrete blocks for

a median price of 130 000 USD [Urr17]. Miami Beach is also elevating its roads by two feet in order to reduce tidal flooding and to help drain water caused by it. Safety measures are also put in place to ensure these elevated roads do not channel flood waters to homes and buildings by using stormwater pumps to remove the excess water. Other cities in the United States like New York City are building a 335 million dollar flood wall. They are five to six feet walls usually built on the coast in order to reduce flooding from tides and storms. Natural infrastructure is also something that can be created in order to absorb excess water caused by flooding. Mangroves, oyster reefs, marshes and seagrass habitats are being built to absorb storm surges which are cost effective and improves a community's natural habitats.

4 Comparative Analysis of Island Nations: The Maldives and Kiribati

As we already know, the rise in global sea levels is causing many problems for low lying communities and coastal cities. Yet a major problem yet to be addressed are the island nations in threat of sinking entirely. An example of this is Tuvalu, better known as the "sinking island". The tiny island nation located in the Polynesian subregion is in threat of going underwater. Due to its thin structure and position directly in the middle of the ocean, it is facing many problems. Island nations are already at a severe disadvantage when it comes to climate change induced natural disasters as they have the disadvantage of location. But hope is not lost, as there are solutions being put in place that have already been successful and can be implemented by other countries. For example, the Maldives is also an island nation in the Indian Ocean facing problems due to rising sea levels. The IPCC has predicted that the seas will rise by 1.1 metres by 2100 which may threaten the existence of the islands. Although this was a problem already addressed by the president of the Maldives in 1992 at the United Nations Earth Summit, before climate change was taken seriously by the world [Ham08]. Maldives president Maumoon Abdul Gayoom initially tried a political approach to this issue by raising awareness about rising sea levels in his country. They were the first country to sign the Kyoto Protocol to reduce global warming through greenhouse gas emissions which was not too effective. Then they implemented a concrete seawall in order to protect against the floods of 1987 [Ham08]. They were able to obtain the 60 million USD by persuading the Japanese government [Ham08]. The president was also able to attract more people to different parts of the Maldives such as Hulhumale due to its cleanliness and wide sand beaches [Ham08]. This is an example of how a good governance structure can make a huge difference in terms of fighting climate change. The Maldives is a good example of how an island nation can solve its different climate related problems but there are some examples of countries that are not doing so well. One of those is Kiribati, another country in the Pacific Ocean. It is said to be the first country to be swallowed by climate change, with an average sea

level rise of 3.2 mm per year [Pal20]. Newly elected president Taneti Maamau is hoping to raise the islands above the ocean in order to fix this problem. They also plan on partnering with their ally China in order to secure their island and prevent China from building a base on Christmas Island. They are also considering dredging the lagoons in order to solve erosion caused by chronic flooding in the capital of Tarawa. There are many similarities between solutions implemented in the past by the Maldives and the current ones that are going to be implemented by Kiribati. In order to properly compare these solutions, it is important to consider the similarities and differences between the geography and government of both these countries. The Maldives is the lowest country in the world with an elevation of only 1.5 metres above sea level. Kiribati has an elevation of 1.8 metres above sea level but its sea levels are rising at a higher rate than Maldives [Pal20] Both the president of Maldives and the newly elected president of Kiribati take climate change seriously as they are prepared to address this issue and bring it to international attention. A major difference between these countries is the development index. Kiribati is the poorest country in Oceania due to farmers suffering from low incomes and lack of infrastructure due to the country's position away from international waters. The Maldives is a middle income country with a large portion of its income coming from tourism and fisheries. It is important to consider these differences, as they play a huge role in what solutions can and cannot be implemented. For example, countries without strong international ties or a good economic system are unable to afford to build seawalls and other infrastructure to withstand these effects. According to a UN report, a quarter of Pacific Islanders live below basic poverty lines. Many island nations also face high unemployment rates as there are often less opportunities for employment among these countries. Many of these countries are also facing issues due to climate induced natural disasters. Extreme flooding is a big problem seen in many of these island nations. Since many island nations also rely on other countries for their resources, this is a partnership source that can be taken advantage of. Similar to how the Maldives and Kiribati took advantage of their international relations with Japan and China. This is key to getting the funds to implement these solutions.

5 Future Infrastructural Solutions

As discussed, the biggest factor involving rising sea levels is glacial melting. The Antarctic Ice Sheet is rapidly declining and scientists are trying to find ways to prevent it from melting or salvage the rest. Glaciologist Mike Wolowick is suggesting building underwater walls at the mouth of the world's biggest glaciers which would change the way they melt or respond to global warming [Rob]. This plan would involve building sills on the seafloor in order to serve as 'artificial glaciers'. Although this proposal would take a lot more research in order to determine whether or not it is feasible and its long term effects. The West Antarctic Ice Sheet differs slightly from the Greenland Ice Sheet as it sits like a bowl. Due to the shape of the WAIS and the fact that most of its water is stored

in the center, for every foot that it recedes, it introduces more water into the ocean than it previously did [Rob]. This means that the WAIS will not recede steadily over time, but rather at an accelerated pace that will be difficult to predict. This is why scientists are unsure as to whether or not sills are going to be effective against glacial melting. Some of Wolowick's computer models are in its early stages but some show stabilization of glaciers.

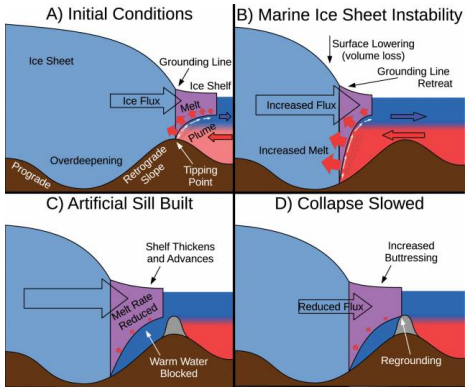

Figure 2: Prototype of a sill from [Liz]

6 Engineering Solutions

6.1 Sills

As initially proposed by glaciologist Michael Wolowick, sills would be large underwater walls composed of sand in its inner layer and an outer layer of boulders. They would be built in Antarctica and Greenland where most of the glaciers extend beyond the land. The barriers would reduce the melting rate by blocking warm water and prevent that water from moving further inland. A concern regarding this solution is the enormous cost of building such a sill or dike in areas due to the great engineering and construction efforts it would take. It is also important to consider the seafloor in which these sills would be built as some areas would be uneven and unstable to support a sill. Wolowick also stated that it is important to consider building them close to areas of dense iceberg melange or underneath floating ice shelves which would further complicate the entire project. There are also a variety of political and legal factors that need to be considered when building these sills, as control of Antarctica is shared by 53 countries so engineers need to obtain the ability to legally construct such masses there. Nevertheless, sills are a new and innovative solution that is being implemented in different parts of the world in order to combat rising sea levels due to glacial melting. They are in their pioneering stages but preliminary studies show that some glaciers are stabilizing and increasing in mass, which

means in the future this potential project could be the key to reversing the effects of glacial melting.

6.2 Dikes

For thousands of years, people in the Netherlands have built embankments called dikes which sit atop major bodies of water in order to control surface runoff from the sea. These structures have been successful in the past in preventing damage incurred by extreme floods and rising sea levels. Now they have been adapted by many countries like China and Canada in order to combat the effects of rising sea levels. In a report to the City of Toronto's general purposes committee this year, the need to raise dikes by 4.7 metres by 2100 was outlined in order to protect against sea level rise [Ham08]. The city has also allocated 130 million USD in funding for flood protection projects. Similarly in China, people are working to fix destroyed dikes in order to combat heavy floods in Eastern China. Dikes also provide historical significance to China as the 1938 Yellow River Flood as it was caused by the Chinese nationalist government opening up dikes in the Yellow River as an attempt to stop the advancements of Japanese forces during the Sino-Japanese War. This caused thousands of people to be displaced and thousands of square miles of farmland to be destroyed. Although it was plotted and intentional, these dikes are also open to malfunction on their own. Although there are many advantages to this system, as dikes are among the cheapest to build when the value of coastal land is low and they provide protection against flooding in low-lying areas [Lea20]. Some disadvantages are the large ecological footprint provided as a result of building dikes as they require the use of many materials and can have detrimental impacts on some coasts [Lea20]. Although unlike sills, this technology is not difficult to manufacture and does not require as much testing to be done prior because they are built as embankments rather than walls underneath the ocean.

Figure 3: Maeslant Barrier in Rotterdam from [Cas09]

6.3 Nature

As with dikes and large walls being used to protect against rising sea levels and flooding, nature is another thing that is not often considered. A major problem to building infrastructure like sills or dikes is the cost, since they require a lot of time, effort and resources to construct. Natural resources such as living organisms can accomplish much of that work with no cost. An example of this is the mangrove forest as it is able to catch sediments and grow with the rising sea levels [Cas09] . Existing dikes can also be ecologically enhanced in order to provide support. Dutch researchers are working on new materials that dikes can be built out of in order to reduce their ecological footprint and make them more efficient [Cas09]. Many of these are being implemented now, such as the tallest dike in the Netherlands being replaced with a sand dune and hybrid dikes being built which are smaller and have nature at the forefront. According to marine biologist Minert de Vries, these natural dikes can also be implemented in many parts of the US including Florida and California. Since both of these states are prone to climate change induced natural disasters and rising sea levels, a better solution should be considered. This new Dutch technology could be adapted by flood management agencies in the US. Jason Needham, a consequence specialist with the US Army Corps of Engineering says devices like Smart Devices (artificial intelligence technology that can be used to detect weather patterns) are costly and ineffective but natural solutions such as those implemented in the Netherlands could be a good solution that restores wetlands. Although the Netherlands and the United States have slightly different approaches to flood control, natural solutions to this collective problem are feasible. There are some disadvantages such as inefficiency due to natural organisms not always being able to protect against extreme natural disasters. Otherwise, this is a cheap and alternative method that can be considered.

7 Implementation

7.1 Sills

Now that potential solutions have been discussed, it is important to consider implementation. As discussed previously, developing countries are the most vulnerable to climate induced natural disasters and rising sea levels. Since sills are not going to be implemented by individual countries due to them only being implemented by private organizations and the scientists working on the Antarctic and Greenland ice sheets. This is a solution that is aimed at reducing the global sea level rise rather than the sea level rise of individual countries. It will still have an overall impact on many countries so it is important to be implemented. Scientists including Michael Wolowick predict that there will still be a good amount of time until this technology is able to be implemented.

7.2 Dikes

Due to the simplicity and low cost of dikes, they are a feasible solution to extreme floods and rising sea levels in coastal areas. They are also effective for use in developing countries where there is not much government funding for these types of projects. For example, as mentioned earlier, countries like Haiti are impoverished due to their wide range of climate induced natural disasters. Due to all these years of infrastructural damage and natural disasters, marshes or dredging would not be a feasible solution towards floods or rising sea levels. Rather, dikes or walls could be implemented in order to solve the issue of floods and erosion caused by hurricanes. Organizations like the Red Cross and other humanitarian relief nonprofits are working towards mitigating risk against natural disasters in Haiti, but prevention could be a better method. Dikes can also be built in island nations like the Maldives and Kiribati. As previously discussed, the Maldives already has built walls in its capital to prevent flooding which have been successful. Similar to those walls, dikes can be built in major water systems to protect against rising sea levels.

7.3 Nature

Natural resources can be implemented in countries that do not have the financial means to support better systems. Although they are not the most effective in terms of protection against major disasters or flooding, they can still be used as a temporary solution. Another advantage of natural solutions like marshes and mangrove forests are the ability for them to be raised naturally which is also cost effective. With dikes and other artificial barriers, they need to be raised according to the sea level rise which is costly and not effective for countries that are not able to maintain it. Countries like Canada can use dikes as they have good municipal government systems and urban planning resources that are able to maintain the dikes and barriers that have been built. China is also advanced in terms of infrastructure and technology so they are able to build and maintain these things. Countries like Haiti do not have good social systems or urban planning resources to maintain such infrastructure. Although they also struggle with obtaining good agricultural and forest land due to the devastation caused by natural disasters, this is also a potential solution. Island nations can benefit from their natural ecosystems and create better dikes such as the Maldives is doing. This new technology hoping to be implemented in Kiribati includes dredging lagoons in order to prevent surface runoff and erosion. Natural resources and methods including dredging and mangrove forests are an effective method for use in developing countries rich in resources.

8 Summary

In summary, global sea level rise is a major issue that is causing many natural disasters and problems for countries around the world. Developing countries are most at risk of not being able to adapt to these new and changing situations due

to their lack of resilience. It is now becoming more and more important that countries are not only able to adapt to these situations but prevent them and reduce their impacts. There are two main problems caused by climate change which includes higher prevalence of natural disasters and rising sea levels due to glacial melting. Many countries are at a vulnerable geographical position when it comes to the natural disasters they are prone to. This is why solutions need to be put in place that are able to be implemented in these countries and can realistically change the way the country can respond to these natural disasters. The three main solutions discussed in the paper are sills, dikes and natural methods used to protect land from rising seas. They are all unique as sills are a new technology that has not yet been implemented due to the extensive research that needs to be conducted in order to determine its effects and efficiency. Dikes have already been in use for thousands of years and are effective in preventing floods but need to be raised according to the sea levels. Therefore, the method a country uses depends upon a case by case analysis of the advantages and disadvantages. Natural methods can be used by any country that has the natural resources necessary to create these types of barriers. Implementing them in countries that do not have the government support and urban planning systems can be difficult but having many options open are possible.

9 Conclusions

In summarization, there are many solutions to climate induced natural disasters that are currently available in different countries around the world. Although many countries do not have the means to implement those solutions. This is due to a variety of factors such as development, government policies, economic or political issues or a lack of awareness. In the research paper, a variety of good examples were compared and analysed to poor examples. This involved a comparative analysis between island nations such as the Maldives and Kiribati and the problems seen in both countries. Many of the studies and research cited in the paper were from scientific journals or experiences from people living in the countries which makes them credible. There was also a comparative analysis between cities in developed countries like Florida and developing countries like Haiti and Bangladesh and their issues. Climate change stretches further than pollution and carbon emissions because it also affects sea levels. A range of sources was employed in finding the depths of climate change on rising sea levels. Countries that are prone to natural disasters are at the most vulnerable because they have to face the effects of climate change such as the earthquakes and hurricanes in Haiti. This places more pressure on the government to resolve those issues which often ends in destabilization and lack of resources available to the public. Luckily there are solutions available such as those highlighted in the paper; sills, dikes and natural barriers. They have their advantages and disadvantages including some being cheaper than others or more effective. This is why it would be better for certain countries to adapt them over others. Since some solutions like sills are not yet fully developed and are still in their

prototyping stages, they cannot be readily implemented.

10 Recommendations and Next Steps

For the future, next steps and further solutions include implementation and change of policies. Certain countries should do a better job of educating the public on social issues including climate change. This does not only include developing countries but other nations like the United States. Since there are many climate deniers and government policies that are going against the progress of climate resilient technology, there are still many problems seen in cities in the country. Other countries where there is corruption and authoritarian policies such as China and Haiti face different issues since the citizens have limited control. There is also limited information as to their contribution to climate change since the global rise in sea levels is caused by a variety of factors and in part to blame by many countries. Recommendations for other countries to take action against this problem is to be more transparent in terms of their contributions to such issues. One noticeable thing during the research was the lack of statistics or information published by government organizations in certain countries. Better access to this information will allow those countries to be held accountable for their actions. Another recommendation would be for organizations and people to invest in climate change resilient infrastructure such as the sills that are currently being developed by glaciologists in the United States. One of the disadvantages listed for sills is their high cost and lack of advancement in terms of research. Michael Wolowick was the lead glaciologist manufacturing these sills and researching their prototype. If more scientists were willing to research this technology and its impacts, it could be implemented sooner. More public policies and services is also a factor that leads to successful progress in tackling climate change related issues. In countries like Haiti, cities and communities are not resilient enough to bounce back when natural disasters occur such as the hurricane of 2010 which the country is still struggling with the effects of. This is in part due to the lack of social services such as infrastructure, roads, healthcare and more. In developed countries, the government is able to provide funding for these services such as rebuilding infrastructure after it has been damaged by natural disasters. Unfortunately due to government corruption, these systems are difficult to maintain. An improvement to the effects of climate induced natural disasters is the improvement of social systems, funding for programs that include infrastructural solutions and raising awareness. Hopefully in the future, the world's most vulnerable communities will no longer struggle with the effects of climate induced sea level rise and find the solutions they need to thrive.

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