

**Prompt**

Between 1901 and 2016, the global mean sea level has risen by 20cm as a result of human-induced warming [1,2]. Not only is sea level projected to continue rising, but this increase is accelerating [2]. Even if global warming were to be limited to 1.5oC above pre-industrial temperatures, sea levels would continue to rise for centuries [3]. This presents unique challenges for Small Island Developing States (SIDS) [4]. As sea levels rise, SIDS (among the least responsible for climate change) face drastic coastline erosion, resulting in increasing floods and land loss [4]. In addition, these countries are generally in areas particularly susceptible to climate-related extreme weather events like cyclones, storm surges and changing precipitation patterns [5]. For these reasons, they require particular attention and help from the international community [6]. Therefore, the UN has tasked you with designing a comprehensive plan to adapt to the effects of climate change in Haiti. Your proposal should consider the geographical challenges of the region as well as the social, cultural and financial factors involved.

## **Abstract**

Haiti today faces significant difficulties in the face of rising sea levels and worsened extreme weather caused by climate change. Increasingly frequent and severe storm surges have overburdened an already fragile water and sanitation infrastructure [3]. Combined with widespread deforestation for agricultural and fuel land, the floods have also led to extensive soil erosion and nutrient leaching [29]. Worryingly, as the majority of Haitians rely on subsistence farming for survival, the worsening soil quality would only serve to exacerbate the current food shortage caused by droughts [6,7]. Haiti's electricity infrastructure also faces problems as frequent hurricanes have destroyed what is remaining of the central electrical grid. Hence, many Haitians have turned to charcoal as their primary source of energy, leading to further deforestation [9]. In light of these issues, we proposed a three-pronged, bottom-up strategy for Haiti focused on absorption, adaptation, and mitigation. In response to current food and sanitation shortages, we proposed an adapted school lunch program along with the use of community-centered, container-based sanitation. In response to soil erosion and decreased yields, we proposed various mitigation strategies including centralized mangrove planting initiatives as well as a shift to more drought-resistant crops. In response to the frequent storm surges, we proposed an Early Warning System (EWS) along with disaster modeling to ensure that damages are minimized as much as possible. In the long run, we proposed a combination of agroforestry, green charcoal, and solar-based microgrids as solutions to deforestation caused by the agriculture and fuel sectors. Additionally, immediate soil-quality improvement can be achieved through crop rotations with legumes such as black beans [31,32]. In addition to these changes, our proposal also focused on empowering the Haitian people themselves. Historic oppression and debts have ruined the Haitian economy and led to political unrest [41]. In building a climate adaptation plan for the country, it is vital that we do not repeat past mistakes and cause worse problems for the future.

## **Introduction**

As one of the countries most affected by climate change, according to the Global Climate Risk Index, Haiti faces significant challenges in the face of rising sea levels and the increased frequency and severity of extreme weather events [1,2]. Infrastructure and agriculture within Haiti are all at risk of being affected, highlighting the urgency for organized efforts aimed at absorption, adaptation, and mitigation to damages.

One of Haiti's most prominent problems today is flooding, which has been fueled by rising sea levels and increased storms [12]. With a large percentage of the population living in coastal zones, climate change has led to increased vulnerability for both the people and the environment [13].

Currently, Haiti's water and sanitation infrastructure is severely underdeveloped, increasing the risk of flooding in the face of increasing rains [3]. Worryingly, due to the lack of proper waste management systems in large cities such as Port-au-Prince, floods carry waste and sewage into poorer sectors surrounding the city leading to the spread of diseases [4]. Ultimately, this waste ends up in the sea, damaging the surrounding environment [5].

Climate change has affected electricity availability in Haiti. Frequent storms continuously damage the already poorly built energy infrastructure [8]. The result is that many Haitians turn to other sources of power, mainly charcoal, leading to increased deforestation [9]. As Haiti's forests shrink, erosion and landslides have become more common and soil health has drastically decreased [10].

Haiti's agricultural sector has also been affected by climate change. With 66% of Haitians engaged in subsistence farming, increasing droughts, flooding, and other natural disasters mean that a large number of people are at risk of malnutrition or starvation [6,7]. Additionally, demand for agricultural land has also led to deforestation [11].

## **Considerations**

There are two main considerations that need to be addressed when looking at climate solutions for Haiti. The first is political instability. The second is poverty and lack of funding.

Haiti has been facing government instability for quite some time. Debt to other countries, environmental disasters, military occupations, and other issues have only exacerbated the political turmoil within the country [14]. Today, one year after the assassination of Haiti's most recent president, the country still does not have a new leader [15]. Hence, it is highly unlikely that any plan taken against climate change will have significant governmental support. Instead, this proposal will take a bottom-up approach, with a focus on community-level changes coupled with aid from NGOs and international organizations.

Additionally, Haiti faces severe economic challenges. The country is extremely dependent on external funding, with remittances constituting about 24% of its GDP [16]. With depreciation of the gourde (Haiti's currency) caused by decreases in the tourism sector, political unrest, and natural disasters, this number is only expected to rise [17]. Therefore, funding for climate solutions will mainly need to be sourced from humanitarian aid. Luckily, Haiti receives a substantial amount of money, around \$1.1 billion for climate mitigation strategies [18]. However, much of this money is misused [18]. Thus, this proposal also aims to alter funding allocation for a greater impact.

## **Plan of Action**

The basis of this proposal is a three-pronged strategy focused on absorption, adaptation, and mitigation. Absorption refers to short-term minimization of exposure to the impacts of climate change. For example, plans to reduce the death toll and structural damage that result from hurricanes in Haiti would fall under absorption. Adaptation refers to long-term strategies that will reduce the impacts of climate change. In response to rising sea levels and frequent floods, adaptation will become ever more important to preserve existing and planned infrastructure. Finally, mitigation refers to policies that work to directly reduce environmental changes. While Haiti is not a significant contributor of CO<sub>2</sub>, accounting for less than 0.03 percent of global emissions, the country is struggling with rapid deforestation along with a widespread use of charcoal for energy [9,19].

### ***Absorption***

The main focus of the absorption aspect of this proposal is to provide a stop-gap for the current issues that the Haitian people face including poor sanitation and food insecurity.

Our proposed solution for poor sanitation is container-based sanitation. One of the main providers of this service, EkoLakay, has seen significant results in its areas of operation with potential to provide clean sanitation to more than 700 million people [20]. However, EkoLakay only operates in urban areas. As such, we propose an expansion of container-based sanitation through a partnership with *bayakou*, local latrine cleaners. Currently, residents of rural areas pool together money to pay for cleaning services, with each household paying around \$8 [21]. Using EkoLakay services as a basis, we estimate that a container-based sanitation system would cost around \$4 a month, meaning that rural communities could potentially save money in the long run [22]. For *bayakou*, the increasing number of contractors means that they either need to accept the extremely low wages offered or risk losing their jobs. Hence, it may be more profitable for them to service container-based sanitation, which would also reduce the danger of their job [21]. In order to lower the costs of container-based sanitation and to insure that *bayakou* receive the maximum amount of profit possible, such a program would need to be funded by non-profit organizations and donations. Luckily, the cost of one container-based toilet is relatively low, around \$22, meaning that overall funding needed would be relatively low as well [22].

In response to food insecurity, we propose an adjusted program for school meals. The World Food Programme currently provides school meals for 100,000 children in Haiti [23]. By adjusting these meals to include larger portions along with some form of cartable food such as bread, students will be able to take home a bit of their food – providing sustenance for younger siblings or other family members that do not attend school. However, a majority of the food would be in a non-cartable format to ensure that students will eat a portion of their meal as well.

### ***Adaptation***

The adaptation portion of this proposal is mainly focused on flooding, droughts, and natural disasters.

One of the most experimentally successful ways to reduce the effects of flooding is to plant mangroves. However, Haiti has seen a slew of such operations, many of which have died out due to lack of funding as operations compete among themselves for money from donors [24]. To address these issues, we propose a concentrated coastal protection initiative. The formation of such an initiative will be organized by the donors themselves, hence ensuring that any operation that does not comply with the initiative will not be funded. Such an initiative will have a strict set of guidelines for money allocation. By centralizing the effort, operations can also share information regarding planting techniques, further increasing the effectiveness of the initiative as a whole. One such technique is the planting of seeds directly along coastlines, rather than in nurseries. This both saves money and also reduces the time needed, thus maintaining local interest in the effort [24]. Additionally, the initiative will not solely be focused on mangrove planting. Resources and money would be allocated to other protection efforts such as local education and protection of existing coastal areas for a holistic approach to flood adaptation.

Droughts currently pose a major issue to Haiti's agricultural sector, leading to food shortages. Luckily, there are a variety of drought-resistant crops that can be grown in the country. For example, sorghum, millet, and pigeon peas are all grown in rural areas in Haiti today [25]. Increasing cultivation of these crops would reduce food shortages and provide a potential source of income for farmers that harvest a surplus. Additionally, technology today provides potential to create better, more drought-resistant crops. For example, scientists are currently working to genetically engineer cassava, or manioc as it is known in Haiti, to be more nutritious [26]. The crop itself is already extremely drought resistant, and a staple in Haiti, so an increase in nutrient content could very well make manioc key to reducing food insecurity in the country.

Natural disasters in Haiti have increased in frequency and severity as a result of climate change. In the past 30 years, the country has been hit by 6 hurricanes which have devastated the area [3]. We propose an Early Warning System (EWS) run through local communities and connected by cell phone networks and radio that warns of floods, hurricanes, and other natural disasters. Historically, cell phones and radio have been shown to work as means of communication after the 2010 Haitian earthquake [27]. In conjunction with the EWS system, disaster analysis and prediction also needs to occur. Luckily, projects such as SMS Lapli have already begun working to provide weather, climate, and water modeling [28]. Hence, there is a high probability that an EWS will be effective in reducing the fatalities and damages associated with extreme weather.

### ***Mitigation***

Lastly, we will look at the mitigation aspect of our proposal, with a focus on Haiti's agriculture and energy insecurity and its relations to deforestation.

Deforestation in Haiti poses a pressing issue. Much of the forest is cut down for agricultural purposes. Unfortunately, the lack of soil protection then leads to increased soil erosion and leaching of nutrients, reducing soil quality and agricultural yields in the long term [29]. Our proposal to solve this issue is a combination of agroforestry and crop rotations. Agroforestry has been proven to help crop growth in drought-prone regions such as Africa's Sahel region by providing shade and a natural irrigation system for plants [30]. A similar system in Haiti would work to reduce soil erosion while also increasing yields in the face of frequent droughts. Crop rotations with nutrient-replenishing plants such as legumes would also help soil quality. While research into rotation possibilities specific to Haiti such as black beans is currently being conducted, crop rotations have been found to be extremely effective at replenishing soil nutrients and improving yields, even during droughts [31,32].

In conjunction with agriculture, another cause of deforestation is charcoal production. Only about 25% of the Haitian population has access to electricity, meaning that residents increasingly turn to charcoal as a means of energy production [33,34]. We propose the usage of greener charcoal sourcing as a solution to this problem. Currently, a large amount of agricultural waste is thrown out. However, much of this waste could be converted into green charcoal with the use of briquette-creating machines [35]. Such production would be self-sustaining after funding for an initial investment to buy equipment as the charcoal market is extremely profitable in Haiti [35]. In conjunction with greener charcoal, our proposal aims to ultimately turn to renewable power through the use of solar-powered microgrids. Solar-powered microgrid technology has seen success in rural regions within Africa where it has provided energy to Kenyan villages [36]. Since these microgrids do not depend on a central electrical grid, they are perfect for Haiti where electricity infrastructure is lackluster and government involvement is undependable [36]. Additionally, while the upfront cost of these microgrids are relatively high, excess power can be stored and sold, resulting in a potential net profit [37].

## **Funding**

There are three main ways we will use to fund the changes we make through our proposal. Depending on the scale of funding needed, money will either come from international organizations and/or NGOs, the Haitian people themselves, or through the tourism industry.

For large scale initiatives such as school meal programs and planting mangroves, a large majority of the funding will need to come from outside sources. As mentioned earlier, Haiti does receive a substantial amount of aid [18]. However, this aid needs to be better allocated so that more of the money goes towards the people rather than to governmental officials. Hence, this proposal aims to increase donations directly towards initiatives with a focus on those run by the Haitian people themselves.

Many of the other initiatives proposed are smaller-scale or self-funding. These initiatives will likely need to be paid for by the Haitian people themselves. However, as mentioned in the proposal, many of these initiatives are actually profitable in the long-term, after an initial investment. Some aid from smaller, private donors, can alleviate the burden of this cost.

Lastly, an option for financing these changes is the tourism industry. Haitian tourism has declined over the years due to fears of violence and political upheaval [38]. However, revival of this sector is possible with a focus on ecotourism. Haiti boasts “more than 25,000 species of plants, animals, fungi, and microbes” with many endemic to the country [39]. Promoting ecotourism would lead to increased awareness and protection of the country’s natural habitats while also generating revenue to fund initiatives. The only caveat is the organizations within Haiti would need to run tours and attractions themselves to prevent diversion of profits.

Along with these 3 funding methods, it is also extremely important that initiatives minimize borrowing as much as possible. With the Haitian government and economy in turmoil, it is uncertain if any of these initiatives will actually be successful. Borrowing money would only exacerbate the pressures on the Haitian people, many of which already live in poverty [40].



## **Conclusion**

While the direct effects of natural disasters such as infrastructure damage and loss of life are frequently the most publicized impacts of climate change, we believe that a sustainable proposal for Haiti must take into account all the interconnected issues associated with extreme weather. Problems that are prevalent today, such as food insecurity, will only be exacerbated over time if efforts are not made right now. As such, our proposal takes a holistic view of the issue and breaks it down into 4 main outcomes – disaster mitigation and adaptation, food security, energy security, and self-sufficiency.

Through more effective technology usage, such as EWS and disaster modeling, the damage caused by extreme weather events can be greatly mitigated. This will lead to a reduction in the human and financial costs of such events. Additionally, the frequency of flooding and storm surges in Haiti can be reduced through coordinated efforts of mangrove planting along coastlines. Improved sanitation systems will then ensure that any storm surge that does manage to penetrate the barrier of the mangrove forests will not lead to widespread sewage overflow like we see today.

In terms of food security, increased droughts and soil degradation pose the largest problems. Through the measures listed in our proposal, we hope to improve nutrient availability for households while also repairing the soil through sustainable agriculture practices. Our aim is to reduce the rate of malnutrition within the country through sustainable means.

We believe that climate change is one of the biggest challenges to energy security within Haiti. Energy infrastructure is repeatedly destroyed in the frequent natural disasters that occur. Hence, we aim to provide energy security through local efforts rather than through a central electricity grid. These solutions – green charcoal and solar-powered microgrids – are easier to repair after natural disasters and are more accessible for the average Haitian.

Finally, the overall objective of our proposal is for the Haitian people to achieve self-sufficiency. The reliance that the country has on international aid is unsustainable and detrimental to the average citizen. The solutions we propose are all focused on empowering the individual so that they can adapt to climate change while also improving their standard of living for the long-term. We believe that climate solutions for Haiti should benefit the Haitian people rather than private corporations or government officials.

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