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Country of choice: Madagascar  
Topic: Climate change  
Focus of Topic: Variability in rainfall patterns

## **Madagascar's Food Insecurity Challenge: A Sustainable Solution for the Changing Climate**

### **Introduction**

Globally, one in eleven people struggle with food insecurity (1). Poverty, climate change, and conflict are three factors that are a significant detriment to food security. Food insecurity impacts physical health by decreasing energy levels and mental health by weakening the ability to concentrate. Those who face this issue often experience other illnesses as a result of their malnutrition, or lack of proper nutrients and vitamins, including heart disease, stunted growth, and other long-term conditions (2). Securing a reliable and stable food supply allows a country to focus on other facets of nation building and management including education, health care, a functional government, and economic development resulting in a virtuous cycle of improvement.

### **Background on the Country and Family**

The nation I chose as my topic of focus is Madagascar, an island country, located off the southeastern coast of Africa. It is the fourth largest island in the world and although part of Africa, the Malagasy people do not consider themselves African due to previous French colonial rule. It was one of the last land masses on earth to be settled (3). In the years between 350 and 550 A.D., humans emigrated from Indonesia and settled in Madagascar. In the seventh century Madagascar attracted merchants from Arabia and Persia, and in the tenth century peoples from Africa arrived. The country had pirate strongholds in the 17th and 18th century, and in the 19th century it was a center for slave trading. The native Merina kingdom had control over the majority of Madagascar from the 16th to the 19th century. In 1896 the French took over and established colonial rule, and in 1960, the Malagasy people gained political independence (4). Since independence, the country has experienced chronic political instability (5). The government in Madagascar is corrupt and not reliable, defamation restricts freedom of press, and lawlessness and poverty is prevalent (6). State institutions in Madagascar are being run for the personal benefit for few of the individuals that have high status in the country. This instability has limited finances and curtailed tourism, which was previously one of the country's main industries (7). Madagascar's current government consists of a semi democratic republic, where a president is elected and serves a five year term (6).

A typical family who lives in Madagascar on average consists of 4.27 people (8). Madagascar is ranked 31st highest country with the highest infant mortality rate with 37.5 deaths every 1,000 live births. Children go to school for ten years in Madagascar with the average citizen reaching an American equivalent of middle school level education (3). The majority of people in Madagascar work in fishing, or forestry and an estimated 85% of Madagascar's population depends on agriculture as their primary livelihood activity (9). Agricultural activity is also where most Malagasy people get their food and meals from.

Diets in Madagascar are centered around one main crop, which is rice; many people depend on this crop because it is cheaper, high in calories, and rich in many vitamins which would be lacking in its absence. A typical meal in Madagascar is called laoka, a dish of rice, served with an accompaniment like vegetables or meat (10). The slash and burn method is used for rice production in Madagascar which is a method

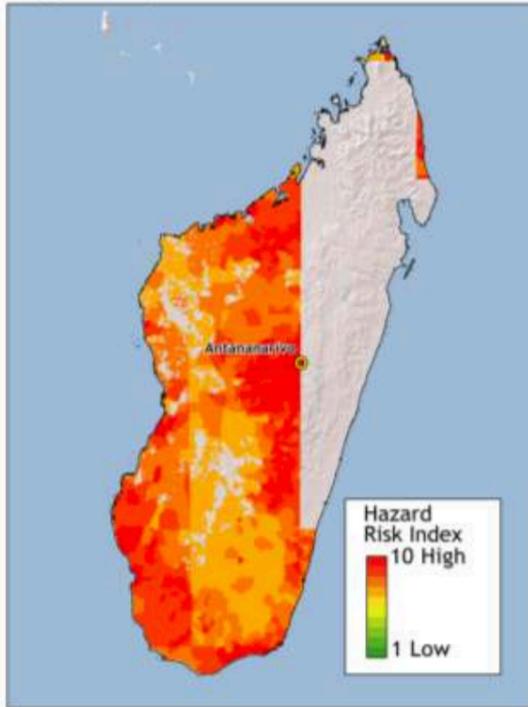
where existing plants are cut down and burned to make more space for cultivation and reintroduce nutrients to the soil.

Madagascar's climate consists of wet and dry seasons with the wet season ranging from November to April, and a dry, hot season spanning from May to October. The United Nations ranks Madagascar as the 4th most vulnerable nation on the planet to the ever-increasing threat of climate change due to the country's high rate of poverty, its ineffective government and its corporate scarcity (11). A rain-shadow effect is created by the presence of relatively low mountain ranges situated along the eastern coastline of Madagascar. As a result of these features of the Madagascan geography, there is a notable decrease in the amount of precipitation that falls on the landmass to the west of these mountains, leading to a significant reduction in rainfall as you move further inland. This plays a crucial role in the shaping of Madagascar's climate, leading to a stark contrast in different areas of the country (12).

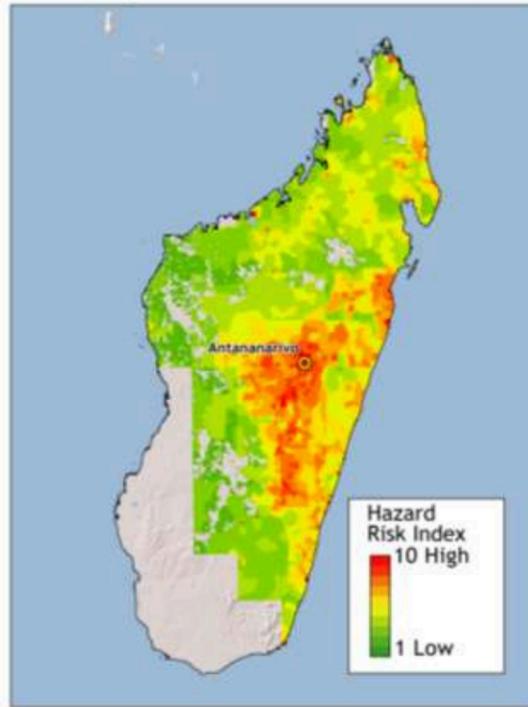
### **Challenge and Impact**

The issue that this paper will focus on is the repeated periods of droughts and floods that hit the country each year secondary to the pressures of climate change and the aforementioned rain-shadow effect. This extreme weather results in distress for the country and leads to an inadequate supply of food for many. Crops in Madagascar are vulnerable to weather stressors, commonly leading to crop failures. During the three decades between 1980 and 2010, Madagascar faced 35 cyclones and floods, five significant drought events, five earthquakes, and six epidemics. These events are occurring more frequently and are becoming increasingly destructive, affecting day to day life. Cyclone intensity is predicted to increase by 46% by the year 2100, a trend that will carry serious implications for Madagascar affecting agriculture, and infrastructure, threatening food security and economic stability (13). Madagascar eastern and central regions are most affected by flooding, and the southern areas affected harshly by droughts. Both prolonged periods of flooding and droughts lead to crop failure in Madagascar. Food insecurity is an enduring issue and is a result of natural disasters occurring in Madagascar and this is only expected to worsen in the foreseeable future.

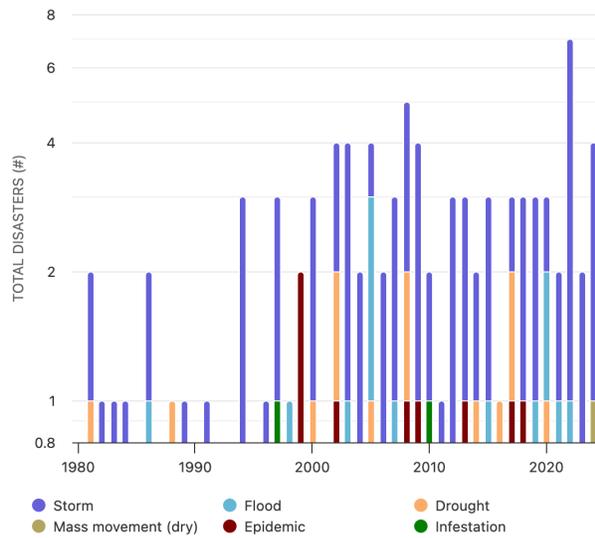
Drought Mortality Risks and Distribution



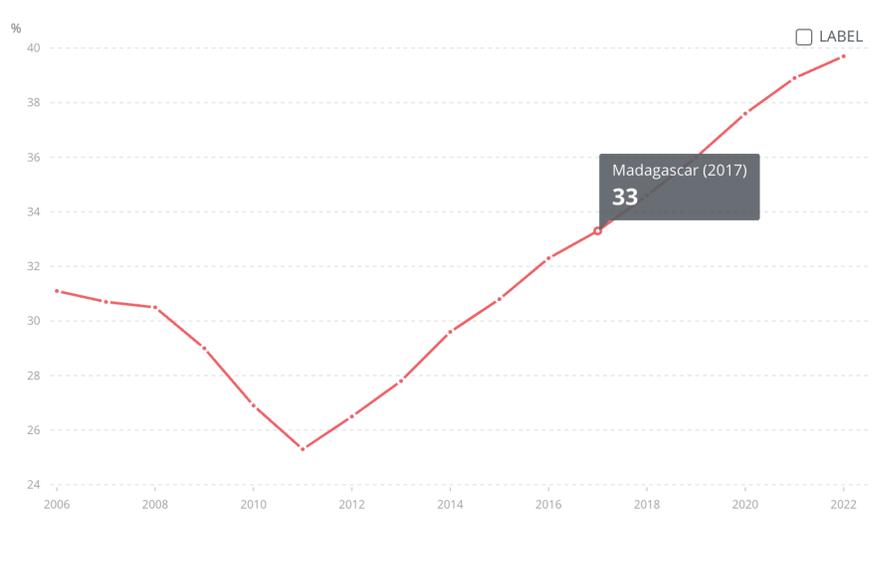
Flood Mortality Risks and Distribution



**Figure 1: Geographic distribution of mortality risk from droughts and floods across Madagascar. (Climate Change Knowledge Portal).**



**Figure 2: Historical data of natural disaster frequency in Madagascar (Climate Change Knowledge Portal).**



**Figure 3: Prevalence of undernourishment (% of population) - Madagascar from 2006 to 2022 (World Bank Open Data).**

One result and negative impact of these harsh conditions is food insecurity. Malagasy people depend on rice to maintain a healthy caloric intake, but since rice is a water intensive crop, it does not grow well during periods of long droughts, and can also be damaged during cyclones where flooding occurs and resulting erosion of soil and nutrients kill or decrease yield. It is reported that drought stress has detrimental effects on the production of rice, especially in the early stages of planting, rice planted in periods of drought can result in a decrease in grain size and number decreasing overall production (14). Although rice typically does grow well in wet conditions, prolonged and extreme flooding can wash it away. In early 2022 between January and March, 60,00 hectares of rice fields were flooded as two cyclones hit Madagascar. It was reported that areas lost as much as 90% of sources of food production methods and systems (15).

As climate change continues to intensify, food insecurity in Madagascar will more than likely intensify in kind. Three in four households in Madagascar report that they do not produce enough rice to feed their family each year (16). In 2021 it was estimated that 22.6% of the population of Malagasy children under five years of age were classified as underweight, implying that they do not receive an adequate supply of food (3).

Due to Madagascar's mountainous terrain, only five percent of the land area can be used for cultivation, and because of this smallholders account for most of the farm owners. The majority of farms are small scale, averaging at about 1.3 hectares (17). Although small scale farms have many benefits, some including sustainability, cultural preservation, local food production, and local economic support, they tend to be overtly vulnerable during natural disasters due to their lack of weather predicting technology, weather resistant crop varieties, and advanced irrigation systems. Due to this the small scale farms in Madagascar suffer harshly as the wet and dry seasons become more extreme.

### **Exploring Solutions**

The country of Madagascar has tried some solutions which include cash distributions, early warnings of climate crises, and food delivery programs. In 2022, the World Food Programme reached 2.2 million drought and cyclones affected people with emergency food and cash assistance. The World Food Programme has also helped the country of Madagascar by providing school meals for young children, ensuring they have a healthy balanced diet, and connecting farmers to markets and contributing training and tools to increase crop production (18). While these solutions help immensely in moments of disaster, ultimately, Madagascar needs a more long term solution for a stable future. Madagascar faces terrain, financing, and infrastructure development challenges which causes current solutions in place to be at a primarily local level. A nationwide solution connecting each end of the country would be beneficial.

While researching the country of Madagascar, some solutions I have concluded that would not be realistic for the country are desalination plants and high tech irrigation systems. Desalination plants require energy and can be very costly, most rural communities do not have access to the electricity needed to use desalination. In my home country, the United States, which is commonly known to be one of the world's wealthiest nations, we do not use desalination plants widely due to the costs. The Claude "Bud" Lewis Carlsbad Desalination plant is located in San Diego, California. This plant supplies roughly 10% of the freshwater consumed by the region's 3.1 million residents, though the cost is nearly twice that of other water sources (19). High tech irrigation systems like drip irrigation require constant maintenance, electricity, and knowledge. Many small scale farms would not be able to maintain or afford these.

Some solutions that have the potential to aid food insecurity, and provide a more stable food supply are rainwater harvesting, mulching, and planting climate-resistant varieties. Rainwater harvesting can reduce dependency on traditional water sources, conserve energy, and help manage stormwater runoff (20). The water derived from it can be used for irrigation, flushing toilets, and when properly filtered, even

drinking. It goes through a process of collection, filtration, storage, then distribution. Using a rainwater harvesting system in Madagascar would manage rainwater locally and store it for use in times of need. Mulching is when a layer of organic material is applied on the surface of the soil around plants. This technique would aim to improve soil moisture retention in areas of water scarcity; this would help plants thrive and reduce the need for frequent irrigation and fertilization. In areas where floods occur, mulch helps to prevent runoff by allowing the water to penetrate the soil rather than flowing off the surface (21). A final solution to this issue is planting climate resistant varieties. Climate resistant varieties help areas of the earth adapt agriculture to the challenges posed by climate change. Drought-resistant crops are bred to use water more efficiently. Flood-resistant crops are constructed to survive in waterlogged conditions (22). A nationwide switch to these varieties would increase the amount of crops that can survive the harsh conditions that take place in Madagascar.

### **My Recommendation**

My recommendation to resolve this crisis in Madagascar is to collect water during periods of heavy rain in Madagascar in rainwater harvesting systems, then to transfer this water to constructed aqueducts and canals which are constructed waterways built to transport mass amounts of water this water transport this water to regions of the country in need of water. This solution would be beneficial to both the flooded regions and the dry regions because it stores and removes water in flooded areas and transports it to areas in need of irrigation. This would support crop growth and reduce crop failure in the two contrasting conditions. This would work toward improving the food insecurity crisis in Madagascar and relieving people who are facing droughts and floods by decreasing the severity of these disasters and directly lead to an increase in food production. In Madagascar, an adequate food supply would encourage people to go beyond the world of agriculture in terms of occupations and allow for exploration in other occupations which would help grow the economy.

My proposed recommendation for Madagascar is optimal because of the periodic droughts and uneven rainfall distribution. Agriculture is a major part of Madagascar's economy and aqueducts can support irrigation networks, especially in areas affected by seasonal droughts. Due to the country's geography, it has rivers and lakes that could serve as water sources and the system could carry water over the uneven terrain. This solution would provide a reliable water source to farmers nationwide.

The Los Angeles aqueduct in the United States is an example of a past waterway project constructed and my proposal is similar to this project. This aqueduct was built between the years of 1908 and 1913, and cost 23 million USD. Water was taken from the Owens Valley to areas hundreds of miles away in need of help to sustain its people and expand the economy. An application was submitted to the City of Los Angeles and was accepted in 1907 when voters approved the bond issue (23). The construction of the aqueduct delivered a stable water supply, allowing the city and agriculture industry in Los Angeles to develop and expand (24). The goal of this project would be to connect the flooded eastern regions with the dry western regions of the country to allow for a stable water supply throughout the country. The country of Madagascar is around 250 miles wide (25), so the distance the aqueduct would span would be similar to Los Angeles. More than 2.5 billion liters of water are delivered daily, supplying around 27 million people and irrigating 750,000 acres of farmland. Although the project is widely recognized for enabling Los Angeles to prosper, it came at the cost of the Owens valley region in eastern California (26). An aqueduct is more suitable for a place like Madagascar because in this case, one region is extremely dry while another region faces extreme floods.

Limitations to this recommendation are the high cost at which it would take to initiate and fund this project, and the maintenance requirements needed to keep the systems functioning properly. Significant funds would need to be raised in order to execute this project. The limited capacity of rainwater harvesting systems is also of concern but larger and multiple tanks could be built for this project, underground storage designs could be installed, and roof designs on houses and buildings with gradual slopes can help convey water into additional storage. These are just some of the many strategies to

overcome this obstacle. Due to the political unreliability of Madagascar, an international development organization would be best suited to organize this project. The World Food Programme with experience working in Madagascar could be a potential organization to execute this project. Financial resources, technical expertise in design and engineering, raw materials and equipment, community engagement, and monitoring would be needed for success. Madagascar does have natural resources necessary including stone, gravel, timber, and clay (27).

Rainwater harvesting and constructed waterways are very sustainable, and are a great way to recycle water, posing little harm to the environment so long as they do not alter existing natural water flow and ecosystems. The design is also economically and socially sustainable with lower irrigation costs and increased climate resilience. This solution would be a very large project to initiate, but would have a substantial, long lasting positive impact for the Malagasy people.

Rice, cassava, maize, and sweet potatoes are the most common crops grown in Madagascar. With an imposed solution like my recommendation, water could be delivered to areas in need and farmers could grow a wider variety of crops with higher nutritional values to ensure all people receive the proper diet they need. In addition crop yields and food availability would increase. This would aim to decrease the amount of malnourished people. Growing crops like Legumes, which typically perform poorly in droughts could increase protein, zinc, magnesium, potassium, and vitamin B intakes. Peanuts could also be grown which are high in protein and calories but low in cost and their production is more feasible if proper irrigation is in place. Improving water infrastructure will lead to community resilience and a stable source of food.

Madagascar has a variety of livestock including zebu cattle, goats, sheep, pigs, and poultry. If more water was available for these herds during periods of drought, there would be a more reliable food source due to healthier livestock. Goat milk and zebu cattle milk also have important vitamins and minerals that could help fight malnutrition in children of young ages and be a reliable source of much needed fat and protein. A study found that greater livestock ownership (measured in tropical livestock units per capita) is associated with greater food security and enhanced diversity in diets for children between the ages of 6 and 23 months (28).

Additionally, if Madagascar improves their water infrastructure to provide a stable source, the country could begin insect cultivation. Water is needed for insect farming to grow feed and maintain a sanitary environment. With a steady source of water, insect farming could be run consistently and on a large scale. An insect cultivation project completed in Kenya and Uganda showed that the cost of feed ingredients for livestock has doubled between the years of 2014 and 2019, this project shows how harvesting the nutrient value of insects can be used as a protein source for the animals. The results showed that out of 28 insect species studied, 92% contained more crude protein than locally available fishmeal (29). Along with using insects to feed livestock, humans have begun to eat insects as well to increase their protein and overall caloric intake. In some cultures they are eaten roasted, fried, or boiled, while in others they have begun to mill insects into a flour used to blend into foods. While these not only deliver essential nutrition, they also meet economic and environmental criteria (30).

## **Conclusion**

Combining a rainwater harvesting system with an aqueduct transport system in Madagascar has the potential to significantly improve public health, enhance water accessibility, support environmental stability, and foster economic development. By capturing rainfall during periods of heavy rain and redistributing it to drought prone areas, the system would balance the extremities of Madagascar's climate. Through implementing long-term water infrastructure solutions, Madagascar could create a path toward

greater food security. The system would reduce the prevalence of waterborne diseases, while also supporting agriculture allowing crops to grow consistently. Access to water is the foundation of stable societies, and with it, Madagascar could expand its agriculture beyond staple crops such as rice and cassava, diversifying diets and improving nutrition for all.

Each year, millions of people are impacted by food insecurity, and the country of Madagascar serves as a clear example of how climate change intensifies it. This paper has addressed how the climate crisis in Madagascar affects food insecurity in the country, while also proposing a solution and recommendations to face this issue to aim to end in stability for the country as a whole. As the earth's climate continues to change, efforts to improve access to food will need to increase substantially. Though there are serious challenges ahead, they are not insurmountable. With cooperation from local governments in Madagascar, international development organizations, and communities, Madagascar can implement sustainable solutions that generate long lasting positive change. While the proposed project requires significant funding, the lasting benefits outweigh the challenges. The implications go beyond feeding the people of Madagascar, this progress would open doors for improvement in education, healthcare, and governance, ensuring the country will break free from its continuous cycle through poverty and instability. Although this paper focuses on the ecological emergency in Madagascar, the same ideas apply globally, as the earth's climate continues to change, efforts addressing food insecurity likewise must intensify. The world as a whole must collaborate to ensure a lack of adequate food supply does not interfere with daily lives. Through investing in innovation and resilience today, we can move toward a future where each individual has the opportunity to thrive.

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**Figure 3** - "Prevalence of undernourishment (% of population) - Madagascar." *World Bank Group*,

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