Kaylee Preble
Dublin Coffman High School
Columbus, OH
Côte d'Ivoire, Effects of Viral Pathogens on Cocoa Production

Côte d'Ivoire: The Country No One Knows

Côte d'Ivoire—or "Ivory Coast"—used to be a French agricultural colony in Western Africa. Following their independence in 1960, Cote d'Ivoire has been a developing country ever since; confusion, civil war, and poverty later engulfed the new country to this day. However, there is hope… Their economy has a huge potential to reconstruct the country, as they are the world's largest producer to date for one natural resource: cacao. As of 2015, Cote d'Ivoire is producing 30% of the world's cocoa, almost doubling that of Ghana, the world's second largest producer at 17% (Mattyasovszky 2015). Unfortunately, cacao is extremely vulnerable to various diseases due to the humid, tropical climate in which it grows. One of these diseases is Swollen Shoot Virus, which infects cacao trees by transmission of mealybugs and infected budwood (Gilmour et al 2012). Aside from insect and direct transmission, there are other issues that cause Swollen Shoot Virus to spread in Cote d'Ivoire: flooding and lack of proper sanitation techniques in rural areas. When diving deeper into the possible resolutions of Swollen Shoot Virus within Cote d'Ivoire, we cannot solve this issue directly. Instead, we must look at several controllable factors that contribute to its transmission while also improving the quality of life for the Ivorian people. After establishing the end goal of stopping Swollen Shoot Virus and improving the quality of Ivorian life, now we must explore the lives of the average Ivorian family.

First, let's talk statistics: Côte d'Ivoire has a GDP per capita of $3,900, while the United States has a GDP per capita of $59,800 (CIA 2017). If you were to do the math, the U.S. GDP per capita exceeds that of Côte d'Ivoire by over 15 times, and looking around at our living conditions, you would imagine that the living conditions in Côte d'Ivoire are more than inadequate—they are *dehumanizing*. To put these conditions into perspective, the average Ivorian family brings in less than $1.25 a day (World Food Programme 2018), in which most of this money comes from the males of the household. Côte d'Ivoire is dominated by a patriarchal way of life, which means that the males in the household are dominant over the females. Traditionally, this way of life also means that the males are working outside jobs while the females stay home and care for the children. However, while the females in an Ivorian household are still expected to perform traditionally feminine duties such as cooking, cleaning, and nursing, a study conducted by the Fair Labor Association (FLA) found that 93% of their interviewed group of women were working in the cocoa industry, whether it be on family farms or cacao plantations

(Fair Labor Association 2014). Unfortunately, due to the dominant patriarchy in Côte d'Ivoire, these women do not receive enough pay to support their families nor are they recognized for their role in the production of cocoa, so we automatically assume that women are not involved in the issue of Swollen Shoot Virus at all. While it may seem that because both men and women in the household are working, they are producing enough money to support their families. This, however, is far from the truth; In fact, nearly half of the Ivorian population live *below* the poverty line (CIA 2015), which in itself is enough to explain the Ivorian way of life: While women can work, own, or maintain their own businesses associated with the cocoa industry, the patriarchal way of life still poses as an obstacle in giving these women the credit and pay they deserve for keeping the cocoa industry afloat… In this regard, it is safe to say that a woman's success in Côte d'Ivoire is based upon her relationships with men.

While my previous assertion may be the normality within Côte d'Ivoire, there are some anomalies; I researched a personal story about a single mother of five children, who started a sweet banana business in order to support her children. She overcame the cultural norms of her area in Western Côte d'Ivoire, and managed to transform herself from a mother barely able to provide one meal a day for her family to a successful business woman who sent two of her eldest sons to high school. Her name is Christine Bamon, and she used the help of the World Food Programme to rebuild the lives of her family. After the author conducted an interview with the single mother, she shared the insight that Bamon gave to families that share her position: "My message to everyone struggling like me is that we have to prepare ourselves to be independent and resilient. I have to keep moving forward and fight, for the sake of my children" (qtd. in Dasylva 2018). Unfortunately, for stories like Bamon's family, this is quite the norm in Côte d'Ivoire; in fact, only a tad over 50% of Ivoirian children finish primary school (CIA 2008), so the fact that Bamon could send not one but *two* of her children to high school is a huge breakthrough considering the societal normalities in Côte d'Ivoire. Bamon is an example to Ivorian women that it is possible to break the cycle of poverty despite the adversity they face… All they have to do is find something that is worth fighting for, and motivate themselves to keep fighting for the sake of their futures. This is exactly what we must help the Ivorian people understand: We cannot move forward in an effort to improve their quality of life if they cannot learn to move past their current oppressive way of life… They must learn to encourage the success of their economy despite the gender of the farmers that make their success possible.

Aside from the oppressive social expectations within Côte d'Ivoire, is also another tragic reality for Ivoirian families: the extremely high risk of contracting an infectious disease, as well as the inability to find a physician capable of treating it. Some of the most common diseases they can get include Diarrhea, Hepatitis A, Typhoid Fever, and Yellow Fever (CIA 2016), all of which can be spread by

inadequate food, improper sanitation, polluted water, and/or transmission by others that are infected. On top of the high risk in getting infected by one of these diseases, there is an extreme lack of physicians that can provide medical attention to treat these diseases. After doing simple math, I have calculated that there is approximately 1 physician per 7,000 people, for an overall population estimated to be 26.2 million people (CIA 2018). In comparison, the United States has an estimated 2.57 physicians per 1,000 people, for an overall population estimated to be 329.2 million people (CIA 2014). To put this factor simply, it is extremely likely that farmers can get sick due to the improper sanitation practices in rural areas, and if these farmers are sick, who will take care of the cacao farms and prevent them from contracting Swollen Shoot Virus? The answer is quite clear: There will be no one. Cacao trees will die, profit will be lost, and the families supported by that profit will experience the excruciating effects of poverty, and there is nothing they can do to stop it.

Aside from the effects of sanitation on the cocoa industry, there is one last factor that must be discussed: flooding. Because most Ivorian cities are located next to rivers or on the coast bordering the Atlantic Ocean, flooding is very, very common. Unfortunately, flooding can have some deadly consequences for Ivoirian families: One, flooding displaces people, houses, and farms, that is one fact. Two, it can also *destroy* people, houses, and farms… Everything these people worked for is swept away by a flood, and this includes the farms that were growing cacao; Millions of dollars are lost in an instant. In a recent pursuit of the World Food Programme, they provided emergency aid to Côte d'Ivoire after a very bad flood; and by bad, some flood waters were up to 2.5 meters deep (Badejo-Sanogo 2018). Not many people died as a result of this flood, but many families were panicked and fled to areas that were not affected by the flooding, which resulted in higher rates of illness and malnourishment, especially for young children. Another effect that can be assumed is that hundreds of cacao farms experienced higher rates of crop loss, as many cacao trees died of ethanol poisoning due to lack of oxygen, which is needed to make energy through Cellular Respiration. If a plant cannot produce enough energy to keep itself alive, then it cannot produce the energy required to reproduce and create seeds. Also, we can assume that debris is spread by a flood, and I found that Swollen Shoot Virus can be spread by infected budwood. How flooding contributes to the cocoa industry and the spread of Swollen Shoot Virus is very clear: cacao trees will die either from ethanol poisoning due to lack of oxygen, or Swollen Shoot Virus will infect cacao trees that were healthy and they will end up dying as well.

To tie all the factors together, imagine this scenario: Hundreds of thousands of women are trying to keep the cacao trees healthy and growing on their farms so they can later sell cocoa to mainstream chocolate companies. But, these women are already struggling with the amount of pay they receive to support their families, as well as buying materials that are needed to help the cacao trees grow. Then

suddenly, a flood comes along; because there is no proper sanitation techniques to get rid of human waste in rural areas, many women soon fall ill with Typhoid Fever and Yellow Fever. The cacao farms later go neglected because there are not enough people to maintain the growth of the cacao trees. Also because of the flood, there are very deep waters across the farms, which soon cause many trees to die from ethanol poisoning; Simultaneously, there are many pieces of debris that washed up on the farms that are infected with Swollen Shoot Virus… Not long after, many cacao trees that survived the flood are now infected with Swollen Shoot Virus, and there is nothing the farmers can do to stop it; Millions of dollars are now lost, all because a flood swept across the country. On that note, it is now time to discuss the solutions to the factors that contribute to the spread of Swollen Shoot Virus.

Let's start with a solution to the frequent flooding: building more canals. Although there are approximately 980 km of waterways in Côte d'Ivoire (CIA 2011), most of those waterways are rivers, which are the source of the issue. Building more canals will allow for water relocation, ultimately improving the consequences when flooding does occur. While there are pros to building canals, there are also some cons when it comes to executing this solution: money and time. While the Ivorian government can provide funding for this project, it may be slightly unreasonable, as they are still recovering from a civil war in the 90's. Funding will most likely come from the United Nations and France, as well as other highly involved organizations such as the World Food Programme. It will be crucial to explain how the Swollen Shoot Virus issue affects the economies of the major chocolate-consuming countries in the world; Once this happens, it will be more likely that these countries will provide financial aid to carry out the canal building project. But, this solution will be fairly expensive. According to History.com, the Panama Canal cost over $350 million to build (History.com Editors 2015), so it may take over $1 billion to complete multiple canals that span across Côte d'Ivoire. However, I believe that if multiple countries and organizations are willing to fund this massive project, I believe the cocoa industry will improve for the better; There may be flooding occasionally, but the consequences will not be as severe as before, and cacao yield and survival will increase in the long term. Also, time is a big factor when it comes to executing this project: Building multiple canals will most likely take over 15 years to complete, with possible added time due to flood season and inadequate working conditions climate-wise. But, let's look at the bright side: jobs will be created by this project, which will boost the economy drastically, and jobs will be available to those that live in rural areas, men and women alike. That also addresses the issue of unemployment rates in Côte d'Ivoire, as many people will be needed to plan, build, and maintain the canals. Not only will this solution help the Ivorian people, it will provide a more stable way of life as well.

Now, let's talk about improving sanitation practices in rural areas: I propose turning human waste into safe, nutrient-rich compost soil that can be used by local farmers and even be marketed as an Ivorian export. Author Rion Nakaya describes an example of this practice in her 2018 article "Transforming Human Poop Into Eco-Friendly Fertilizer" by an organization based in Haiti called Sustainable Organic Integrated Livelihoods (SOIL). They come by once a week in what they call a "Poop Mobile", and they collect the waste gathered by each family. They later transport it to a specialized facility that removes any harmful bacteria and pathogens that may be present, mix the waste with a sugary by-product from rum production, leave it alone for 8 months and violà: you have compost. However, many people may ask if this project will be successful in Côte d'Ivoire. According to SOIL's website, the main reasons why their project in Haiti has been successful is because they connect with the communities they work with through communication, include the community on every step of their projects, buy materials locally, create solutions that will become financially self-supporting, and value knowledge from both formal training and life experiences from those living in the communities they serve (SOIL 2018). I believe that SOIL may give the Ivorian people a good start to improving sanitation within their country, as long as we partner with them to put this project into motion. I believe that by partnering with SOIL to get this project started, it will eventually lead to Cote d'Ivoire no longer depending on the organization to keep this project successful, and Ivorian people will have new opportunities for jobs in the future. Also, for the sake of making this solution more efficient, instead of collecting waste from each and every family individually, SOIL and the Ivorian government can work together to establish checkpoints in which the families can drop off their waste and the mobile can stop at each checkpoint to collect it. Although this process may take some time, such as producing the compost and building the facilities where these people can make it, this solution is one that is promising and helpful for Ivorian families; this plan could possibly prevent more foodborne and infectious disease outbreaks, and in the long run, ultimately improve quality of life for the better.

Lastly, let's talk about the big culprit for cocoa production: Swollen Shoot Virus. This disease is rather a complex one, as it affects the DNA of cacao cells and ultimately leads to death. Unfortunately, viruses cannot be treated like bacterial infections; With bacterial infections, you can use antibiotics or certain chemicals to kill the bacteria and terminate the infection. With viruses though, they inject their own DNA into host cells, which reprogram the host cells to create more copies of the virus. Viruses are very difficult to destroy for this very reason, as it is extremely hard to control the reproduction of the virus. I have researched multiple articles to find an appropriate solution to this issue, but ultimately, they all lead to one final solution: GMOs. Think about it: Mealybugs are the main vector for Swollen Shoot Virus transmission, and in further research, they can only survive and reproduce in humid climates (Pundt

2013). By developing a strain of cacao that can survive (and grow) in arid and/or semi-arid climates, this would be a huge breakthrough for cocoa production in Côte d'Ivoire. Côte d'Ivoire is even divided between a semi-arid climate in the North and a tropical climate in the South; it's almost perfect. Although, we're not done yet. As of right now, there are already scientists at the University of California Berkeley investigating the use of CRISPR technology in editing the cacao gene responsible for survival in certain climatic conditions. Since these scientists are working on a strain that can survive in semi-arid climates, there are several conditions that the new strand of cacao needs to endure: Minimal rainfall, extreme changes in temperatures, and high UV radiation. To begin their research, I suggest looking into a genus of xerophilic bacteria called Actinobacteria. This genus is composed of tens of thousands of different species of bacteria, and thousands of those species have been found to survive in semi-arid and arid climates. I also suggest studying plants and organisms native to Côte d'Ivoire's semi-arid region, as this will help scientists understand what kinds of adaptations they need to research in order to develop a strain of cacao tree that will survive in that specific climate; By encouraging further research and understanding of Côte d'Ivoire's semi-arid region, it will increase the chances of this solution succeeding in the future.

However, there is still a huge risk to be taken in this research: it is uncertain if the pursuit of these scientists will succeed. Nevertheless, succeeding would be a huge breakthrough in keeping cocoa production alive and well… All we can do is hope. In an article by Kay Vandette about the potential this project has, she says, "If successful, gene edited crops like the cacao plant could help ease global food shortages brought on by the weather extremes, drought, and diseases that climate change is projected to cause and worsen" (Vandette 2018). This is exactly right, as the extinction of cocoa is fairly probable… In the meantime, prevention of Swollen Shoot Virus transmission is our only option, such as removing infected trees and avoiding transport of cocoa tree parts from place to place (Gilmour et al 2012), as this could ultimately be the difference between introducing this virus to a new region or keeping it virus-free.

To wrap up research on this issue within Côte d'Ivoire, let's go through the basics: Flooding, Sanitation, Poverty, and Swollen Shoot Virus all affect the production of cocoa. When the economic state of Côte d'Ivoire changes, so does the quality of life for Ivorian families. So, by employing the proposed solutions of building canals, producing eco-friendly compost, and supporting GMO research will help bring hope to the lives of the Ivorian people, knowing that they have the possibility as well as the ability to create stable livelihoods, and break the cycle of poverty. Although these solutions will not solve all of the issues present in Côte d'Ivoire, they will at least start the journey of building Côte d'Ivoire into a strong, successful country, able to provide for its people.

Works Cited

Advameg Inc. “Ivoirians.” *Countries and Their Cultures*, 2019, www.everyculture.com/wc/Costa-Rica-to-Georgia/Ivoirians.html.

Amede, Louis. “New Agriculturist.” *New Agriculturist: Country Profile - Afghanistan*, Dec. 2011, www.new-ag.info/en/country/profile.php?a=2317.

Appau, Felix. “Ghana, Cote D'Ivoire Launch Swollen Shoot Virus Control Programme.” *MyJoyOnline.com*, 2018, www.myjoyonline.com/business/2018/August-28th/ghana-cote-divoire-launch-swollen-shoot-virus-control-programme.php.

Badejo-Sanogo, Adeyinka. *Information Note of Immediate Response Delegation of Authority to the Country Director*. Adeyinka Badejo-Sanogo, 2018, pp. 1–4, *Information Note of Immediate Response Delegation of Authority to the Country Director*, docs.wfp.org/api/documents/WFP-0000102154/download/?_ga=2.82950558.985414182.1548888836-116818348.1548888836.

Central Intelligence Agency (CIA). “The World Factbook: United States.” *Central Intelligence Agency*, Central Intelligence Agency, 1 Feb. 2018, www.cia.gov/library/publications/the-world-factbook/geos/us.html.

Central Intelligence Agency (CIA). “The World Factbook: Cote D'Ivoire.” *Central Intelligence Agency*, Central Intelligence Agency, 1 Feb. 2018, www.cia.gov/library/publications/the-world-factbook/geos/iv.html.

Dasylva, Marie. “Finding Food Autonomy: Rebuilding, Not Just Surviving.” *World Food Programme Insight*, World Food Programme Insight, 17 July 2018, insight.wfp.org/finding-food-autonomy-no-longer-just-surviving-but-rebuilding-72dde64a4dff?_ga=2.121205120.985414182.1548888836-116818348.1548888836.

Editors, History.com. “Panama Canal.” *History.com*, A&E Television Networks, 4 Aug. 2015, www.history.com/topics/landmarks/panama-canal.

Fair Labor Association (FLA). “ASSESSING WOMEN’S ROLES IN NESTLÉ’S IVORY COAST COCOA SUPPLY CHAIN.” *Improving Workers Lives Worldwide*, July 2014, www.fairlabor.org/sites/default/files/documents/reports/nestle_gender_report_7-9-14_0.pdf.

Gilmour, Martin, et al. “Minimizing the Risk of Spreading Cocoa Swollen Shoot Virus Disease.” *Brochure Cocoa Swollen Shoot Virus Disease*, World Agroforestry Centre (ICRAF), 2012, www.worldagroforestry.org/sites/default/files/Brochure-Cocoa-Swollen-Shoot-Virus-Disease.pdf

.

Mattyasovszky, Miklos. “Top 10 Cocoa Producing Countries.” *World Atlas*, Worldatlas, 23 Apr. 2015, www.worldatlas.com/articles/top-10-cocoa-producing-countries.html.

Miaschi, John. "What Are The Characteristics Of A Semi-arid Climate Pattern?" WorldAtlas, Nov. 13, 2017, worldatlas.com/articles/what-are-the-characteristics-of-a-semi-arid-climate-pattern.html.

Mohammadipanah, Fatemeh, and Joachim Wink. “Actinobacteria from Arid and Desert Habitats: Diversity and Biological Activity.” *Frontiers in Microbiology*, Frontiers Media S.A., 28 Jan. 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC4729944/.

Mundt, Robert John, and Nancy Ellen Lawler. “Côte D'Ivoire.” *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 8 Feb. 2019, www.britannica.com/place/Cote-dIvoire/Climate.

Nakaya, Rion. “Transforming Human Poop Into Eco-Friendly Fertilizer.” *The Kid Should See This*, 5 Feb. 2018, thekidshouldseethis.com/post/transforming-human-poop-into-eco-friendly-fertilizer.

Pundt, Leane. “Managing Mealybugs in the Greenhouse.” *Managing Western Flower Thrips on Greenhouse Crops - CT Integrated Pest Management Program*, 2013, ipm.uconn.edu/documents/raw2/html/455.php?display=print.

Sustainable Organic Integrated Livelihoods (SOIL). “How We're Different.” *SOIL Haiti*, 2018,

www.oursoil.org/how-were-different/.

Vandette, Kay. “Genetically Modified Cacao Could Stop Chocolate from Running out • Earth.com.” *Earth.com*, 2018, www.earth.com/news/genetically-modified-cacao-chocolate/.

World Food Programme (WFP). “Côte D'Ivoire.” *World Food Programme*, 2019, www1.wfp.org/countries/cote-divoire.

World Food Programme. “Cote D'Ivoire Transitional ICSP (January - December 2018).” *World Food Programme*, 2017, www1.wfp.org/operations/ci01-cote-divoire-transitional-icsp-january-december-2018.

WorldAtlas. “Africa/.” *World Atlas*, Worldatlas, 2019, www.worldatlas.com/webimage/countrys/africa/cotedivoire/ciland.htm.