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Factor Two: Nepal - Water and Sanitation

Water and Sanitation is one of the most lethal issues facing food security today, and harms many third world countries. Nepal is a landlocked country in South Asia that falls victim to the many water sanitation issues in this world. Nepal faces many issues in terms of water and sanitation after the earthquake they endured in 2015. The access to clean water in Nepal is difficult, and the water available poisons the citizens of Nepal. With 10.8 million people in Nepal lacking access to improved sanitation along with 3.8 million lacking access to basic water services, it is necessary to help Nepal out of their water crisis.

The challenge that is faced by Nepal is to provide clean water for drinking as well as for sanitation to allow for healthy hygiene for citizens. The water is far from safe. The 2015 Earthquake in Nepal killed nearly 9,000 people as well as destroyed villages along with their water systems. This ultimately lead to a shortage of clean water, leaving many victims to the danger of simply drinking water. The main threat to their water is the E. coli bacteria that can cause severe diarrhea along with kidney failure, and ultimately death. (The Mayo Clinic, 2018) Despite being one of the most water abundant countries in the world, they struggle to provide water for families to use. Much of the water has become contaminated through the disposal of waste and sewage into the lakes and rivers that run through the country. (“Children of Nepal”, 2017)

As a country, Nepal faces many barriers that stop it from progressing its people as well as progressing as a nation. One of the main issues is the inability to enhance their agricultural aspect of the economy in order to help grow it. Nepal opts for a more traditional approach to farming, meaning that their means of production are not advanced. Often, they fail to modernize the agriculture, allowing for crops to be overtaken by pests and weeds. These pests often infect plants as well as can carry water borne illnesses to livestock. Another issue is their failure to implement efficient irrigation systems. Less than 20% of farms have an irrigation system for cultivable land. This leaves farmers to rely on the monsoon seasons which have no reliable pattern or serve as a sure way to water crops. (Pokharel, 2017) The lack of government intervention also hurts the agricultural side of their economy. Many farms in the US and other countries are subsidised in order to increase production of the products, while in Nepal the government does not give money to farmers. This makes it so that farming cannot grow as well as forces the Nepalese farmers to remain in poverty. Many farmers are subjected into taking out loans, and pass on the debt to their children. This causes debt to run rampant in the farming community, making it an unappealing business. The government also fails to fund research in order to help the farming industry. They fail to give money to research to figure out the best crops for Nepal and possibly soil treatments. Another barrier faced by the citizens is their access to these foods. Transportation for produce is rare and often the food rots away. The big issue is with fruits and grains because they are unable to store them they are unable to sell them in many areas. This caused the cost for these fruits to go down where they are sold because of the high concentration of product, leaving the farmers with barely enough money to break even. These widespread issues leave adults and children with only a fraction of the nutrition necessary to pursue a healthy life. (Kathmandu, 2018)

The lack of water and sanitation leads to many parents having no choice but to use the poisonous water for them and their children. The earthquake left many citizens in poverty, and dependent on the government with almost no income. Daya Laxmi is an extreme case of poverty in Nepal, and currently resides at a government camp after the earthquake claimed her village. The government of Nepal has

become neglectful to their citizens, leading access to water completely in the hands of the people. Mothers like Laxmi rely on well water that is contaminated with poisonous strands of E. coli. (The Mayo Clinic, 2018) Buying water, like many people in poverty, is not an option for her family. At the hardest point in her life, her and her family lived on only \$1USD a day, so wells were the only choice she had. She is not alone in the need for better water, and her situation is in no means rare. The earthquake destroyed many villages, almost none having being rebuilt as of January 2019. The mother and two children live on a government campground where she makes her money selling clay items as well as receiving money from government relief funds. Much of the families diet is rice, which becomes dangerous due to the water it is grown in as well as the water it is cooked in. Laxmi claims that the rice is blackened by the E. coli infected water, but due to the scarcity of food, she is forced to feed it to her family. Laxmi can be seen as a model for the average family in Nepal. Some families use farming as a source of income, with about 2,721,963 farms around 0.46 hectares. This means that around 66% of the population is involved in the farming sector of agriculture. These family farms are what the communities in Nepal thrive on, however the food produced has no way of escaping the E. coli infection. (“Water in Kathmandu”, 2018)

Even in more developed areas, Nepal struggles to provide safe water and Sanitation. Kathmandu Valley is the most developed and populated area in Nepal. They have more money, averaging at about 12,000 USD a year. ("The World," 2018) The unemployment rate is around 3.4% which is relatively low. The city has over 4 million residents that use 84 million gallons a day, however only 20% is able to be supplied. This leads the rest of the water to be found in neighboring lakes and rivers. However, the growing population of the city causes 150 tons of daily waste to be dumped into those lakes and rivers, harming many of the citizens. This leads to around one fifth of the households not having access to clean water in the Kathmandu. (Nepal Earthquake, 2019)

The dangerous water has greatly impacted the lives of those involved in agriculture especially after the earthquake. The main crop that Nepal produces and relies on as a food source is rice. The damage ruined irrigation systems for farmers and the toxic water made the crops dangerous to consume. In addition, the water used to cook the rice further contaminates it with E. coli. The water situation has also negatively impacted the ability to keep livestock for many families. About eighty percent of families depend on their livestock, causing many of these families to suffer due to the water. The E. coli has spread from the water to the livestock making the harvesting and production of meat unsafe. (Pokharel, 2017) The water and sanitation crisis has led to many aspects of their agriculture to fall leaving the country in economic distress. In addition, Nepal is an agro- biodiverse country allowing for local farms to thrive. Some crops produced are corn, millet, wheat, and barley although these are not necessarily profitable. More lucrative crops are lentil, pigeon pea, soybeans, as well as horsegram. These crops are just as prone to infection with E. coli as rice is. This makes it difficult for crops to be exported and therefore reduces the capability of commercial farming. Commercial farming is genetically modified food that is able to resist pests and mold, as well as being grown on a massive scale. These means of production can be a source of income for a country's economy, however the water infections sabotage the potential of the country. This leaves Nepal unable to fully capitalize on its high concentration of water. This continues the cycle of poverty in Nepal seeing that they are unable to grow their economy leaving their GDP per capita at 835 USD. Essentially the water crisis is causing the countries exports to be limited leaving the citizens to suffer living far below the poverty line. (“Water in Kathmandu,” 2018)

Countries in crisis need awareness so that the public is aware of the issue. That is the first step for Nepal to start to recover from this water crisis is to use external sources to raise money. Money that is currently being fundraised is being put towards giving water filters to poor rural areas in order to reduce the amount of infected water in their system. This is a preventative method in order to reduce illness and exposure for families that already have limited health care. In addition, public knowledge among the citizens can help

create push back an advocacy for the government to give more aid towards water pollution. Unfortunately, throwing money at an issue will not help this nation as well as further other nations. The solution to clean water lies within the science of genetically modified bacteria. In this case adding bacteria to the water might be the solution. *E. coli*'s natural microbial predator is *B. bacteriovorus*. This bacteria is known to denature all strands of *E. coli* which essentially allows water with *B. bacteriovorus* to limit the danger it poses to humans. The microbial benefits of *B. bacteriovorus* is that it is fast moving, and can spread quickly. The bacteria ideally would be able to denature the *E. coli* when added to rivers ponds or springs. (Harini, Aljiya, & Hedgie, 2016) This biocontrol agent is a potential answer to eliminating *E. coli*. The natural environment for *B. bacteriovorus* is between twenty eight and thirty degrees celsius. Unfortunately, this does not match with the environment of Nepal. The biocontrol agent has to be altered to be able to stand the cooler environment. One option is to alter the DNA using CRISPR. CRISPR splices DNA and allows for genes to be inserted to help create desirable traits. In this case, the gene therapy allows for the development of the tolerance of a colder environment. ("What Are Genome," 2019) This solution ensures that the water will pose a lower health risk for the people of Nepal.

The bacteria works to destroy *E. coli* through five steps creating an extremely effective way to purify water. The bacterium starts by attaching itself the outer membrane of the *E. coli* which breaks the outer cell wall while releasing hormones. *B. bacteriovorus* then penetrates the cell membrane. After the bacterium has access to the periplasm the enzyme hydrolytic is released in order to break down the *E. coli* as a food source for the bacterium. Once the bacterium grows and exhausts the *E. coli*, it can then be divided into fifteen additional cells. This fast reproduction rate allows for this to be invasive, and extremely effective. They live for about three to five hours and in that time can multiple thousands of times. The amount of bacteria grows and shrinks with the supply of *E. coli* that is present at a given time. (Harini, Aljiya, & Hedgie, 2016)

The solution in theory is great, but implementing it presents many issues considering the culture and education in Nepal. The solution is not the most straightforward, and can be difficult for people without a formal education system to understand. Their education system is the youngest in the world and relies heavily on schooling from religious sanctuaries. The informal education can lead to the solution being misunderstood by the citizens of Nepal. To the population it will be difficult to understand that bacteria can help them since bacteria has a negative connotation due to *E. coli* being a type of bacteria. The only viable option is to bring in diplomats from the United States, where the study would be conducted, to effectively educate remote villages through training locals. Locals in the villages are more likely to be able to convey the water treatment methods in a way to avoid distrust towards the product. This is not an easy task by any means. The hope is that people will be receptive and understanding of the water treatment if the information is being relayed by people that they trust, rather than foreigners.

The study would best be conducted and funded by a non profit organisation such as "The Water Project" and "WaterAid US" because they already have a relationship with Nepal. Both these organisations have already built a relationship with Nepal through providing water during their times of need. This relationship is vital to having an efficient implementation of this solution (Suwal, 2017). Using an organisation that fully understands the culture as well as has the trust of Nepal will ensure less pushback. The production facilities for packaging is most viable in the United States due to the regulations of packaging and shipping facilities ensuring safe practices. The packaging of the product must be efficient and easy to implement, since the product is a bacteria must stay alive in the transport conditions. This study would also have to be funded that way the solution can be the most effective and easily spread throughout the villages of Nepal. The solution is so efficient because the water only has to be treated once due to the high reproduction rate of *B. bacteriovorus*. The single treatment reduces prices drastically from traditional filters.

This solution works hand in hand with farmers to help create healthy crops as well. In order for the water to work for the nation it has to be compatible with crops. The main crops farmed in Nepal are maize, rice, barley and wheat. ("Nepal at a Glance," 2019) These plants possess little to no biopolymers that are preyed on by *B. bacteriovorus*. This ensures that these crops will not introduce new hosts to the bacterium making it safe for farming purposes. However, safety precautions have to be taken before implementing the solution to ensure that the farmers are not put in harm's way. As mentioned before, Nepal relies on their nation to provide food for them, and they rely on the agricultural system to provide an income. (Harini, Aljiya, & Hedgie, 2016) Lab based testing using plant cells as well as host bacteria in plants to ensure the safety of the crop. The tests can further the research within *B. bacteriovorus* which can be used later as a precedent for new research involving water filtration on farms.

So there is clean drinking water... now what? Now everything changes for the country of Nepal. Clean drinking water is the gateway for the country to grow its economy, population, education, and overall change the lives of millions for the better. Let's start for Daya Laxmi, the Nepalese woman who lived in the government camp. With clean water she would be able to move out of the camp (that supplied her water) and go to an area where she could be employed. Her children would no longer live with the reality of dying due to waterborne illness and have a nutritional diet. With freedom from the government camp, her children would be able to receive an education that could change generations to come. But it does not stop there. With clean drinking water, new irrigation systems will have a beneficial impact on farms as well as live stock being less likely to die from waterborne illnesses or harm people. This leads to higher incomes for farmers which can combat poverty for 66% of the nation. The nation can effectively switch over to commercial farming and allow for goods such as rice to be exported therefore growing the GDP of the nation. The population can finally flourish. Thousands of children will be saved from waterborne illness death, specifically those caused by *E. coli*. Education will spread amongst the youth. Availability of water at school is proven to increase attendance and with clean water education will become more of a focal point for children. (Pokharel, 2017) This solution does not solve all the countries problems, but it is a great place to start. It does not only further Nepal, but can be used to help the countless other nations that struggle with *E. coli* populated waters. This study can open up sectors of microbial sanitation solutions for all different types of invasive bacteria as well as animal populations. The solution is for more than just one problem and inherently will be the catalyst for change throughout the future.

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