Kiran Marla
Pleasant Valley High School
Bettendorf, Iowa
India, Water and Sanitation

Filtration Systems and Rainwater Harvesting: A Solution to India's Water and Sanitation Issues

2.64 billion people, about 25% of the world's population, do not have access to adequate sanitation, which can cause many health problems. In fact, it is estimated that 21% of the communicable diseases in India are related to a lack of clean water and sanitation. This percentage is so high partly due to the fact that 522 million people in India practice open defecation ("India Water Crisis - Clean Water In India"). India also has a large population density, especially in its urban areas, with Mumbai, the largest city in India, containing 67,300 people per square mile (Smith). Two problems associated with high population density are adverse sanitation conditions and poor access to safe drinking water. With a lack of clean water, 272 million days of school are missed due to diarrhea alone ("Lack of Safe Water and Sanitation in Schools Affects Children's Learning – and Their Lives"). India in particular is a country in which the issue of clean water and sanitation needs to be addressed because it is home to 1 billion people, making India the second largest country by population. Three solutions could help meet the challenge of access to clean water and sanitation in India: 1. Improving the infrastructure for filtration systems 2. Upscaling rainwater harvesting systems 3. Using crop residue as a renewable energy source through a process called gasification.

To better understand the unique water challenge in India it is important to consider the cultural, geographical, and political context of the country. India is a peninsula located in southern Asia with a mountain-filled northern border and ocean-encapsulated southern border. The country is a Federal Parliamentary Republic state with 3 branches of government: executive, legislative, and judicial. The population distribution of the country is not homogenous, with 33.5% of people living in urban areas and a rather high rate of urbanization of 2.5% (rate of urbanization in the US is 0.99%) (*The World Factbook — Central Intelligence Agency*). Typical jobs in India are in industries such as agriculture and construction. In rural populations particularly, the economy is heavily focused on agriculture, with 60% of the rural population directly or indirectly supporting agribusiness (Kharsai). A great deal of land is used to support this industry; in fact 394.6 million acres of land is cultivated for farming (Himani). The average farm size is about 2.84 acres, and less than 1% of landowners operate land larger than 24.7 acres (IANS). This is very small compared to the average farm size in America, which is 250 acres. The small farm size contributes to farm owners bearing a tremendous maintenance cost per capita. In fact, this incredibly high cost is one of the biggest reasons leading to the more than 200,000 suicides by farmers since 1997 (Shiva).

The fact that India's economy is largely agricultural-based highlights the significance of India's water sanitation issues because many farmers practice crop residue burning since it is a cost-effective way to get rid of straw in the soil after harvesting. Tilling crops is labor intensive compared to using burning one matchstick to have an entire field ready to be harvested ("Agriculture | Province of Manitoba"). However, crop burning has detrimental effects to India's water sanitation because this practice leads to air pollution and subsequently polluted acid rain, which worsens the quality of the water (*Farmers' Unchecked Crop Burning Fuels India's Air Pollution - The New York Times*). This rainwater also has drastic effects to

ecosystems; when acid rain flows through soil, it releases aluminum into the water and lowers pH, causing many species to die. Acid rain also removes nutrients necessary for plants' survival from the ground. In 2008, India's farms produced 620 million tons of crop residue, 16 percent of which was burned. Recently, India's government created strict rules regarding crop residue burning (*India's Burning Issue of Crop Burning Takes a New Turn*). However, due the difficulty of enforcing these types of laws because of the vast population, it is nearly impossible to approach this problem from a legislative standpoint.

A traditional family in India lives as a joint family, 3-4 generations living in the same household. However, as India is rapidly modernizing, families do not always live in the same household. More people are looking for more opportunities away from home, especially in urban areas (*India - Family Life And Family Values*). The average house size of urban areas is about 504 square feet, and access to electricity is limited. For example, in metropolitan Delhi, the capital of India (population of 19 million), about half the population lives without electricity. The average house has poor construction and illogical floor plans (*Housing in India*). The average wage is about 272.19 Indian rupees per day, or 1527 dollars per year, and most families are often too poor and lack the resources to afford basic services such as sanitized water (*India Average Daily Wage Rate*). Also, wealth distribution is a prevalent issue, with the GINI index - quantifies wealth distribution on a scale 1-100 such that 100 is money is least distributed – of 35.2 (*GINI Index (World Bank Estimate) | Data*). Put into perspective, India's richest ten percent holds 370 times the wealth the poorest hold, and since the 2000's the top ten percent has continued becoming wealthier (Rukmini).

Many of the Indians leaving their homes to look for opportunities end up living in poverty without safe water and sanitation. This is especially a problem in urban slums; 50% of Mumbai's population lives in informal settlements, where people often lack access to clean water and sanitation (Ratan). This forces them to use dirty community toilets or defecate in the open; the latter can lead to air and water pollution through microbial contamination (*Advantages and Disadvantages of Rainwater Harvesting - Conserve Energy Future*). It is also important to note that as with many global problems, water and sanitation issues affect demographic classes (sex, age, geography) differently: Studies show that in urban slums, adolescent girls were more vulnerable to sexual abuse and harassment after open defecation. Also, the elderly were more prone to injuring themselves when going out into the fields at night to defecate. ("*State of Urban Water and Sanitation in India"*). Fortunately, trends show that access to toilets and clean water has been increasing in both rural and urban areas due to the work of organizations like WASH, WSP, and WaterAid. Many organizations have been working with the government to address issues associated with low socioeconomic housing areas. In fact, the Indian government has pursued an ambitious plan called the Swachh Bharat Mission, which aims to end open defecation by 2019 through building toilets and changing behaviors at the community level (*Projects : IN Swachh Bharat Mission Support Operation | The World Bank*). Also, USAID works with the Indian government to have affordable sanitation/drinking water by training members of communities to build toilets and spreading awareness about good hygiene and the dangers of open defecation (*Partnership for Water Sanitation and Hygiene (WASH) | India | U.S. Agency for International Development*). Similarly, WaterAid also relies on donations to produce well-functioning toilets that are available for everyone.

My first proposal is aimed at addressing the issue of access to clean water and sanitation in urban areas by looking at existing infrastructure. Due to the work by some of the above-mentioned organizations, there is

a significant amount of investment in the construction and maintenance of toilets, but a limitation of these organizations' solutions is the failure to address some fundamental problems with India's sanitation infrastructure in a sustainable manner: of the urban households that have toilets, only 32.7% are connected to a sewage system. Even for those toilets that are connected to sewage systems, the treatment capacity of filtration systems for sewage is only 37%. In addition, of the treatment systems built, only 64% are functional (Mallapur). These are major structural issues that can be alleviated considering 1 in 6 urban residents in India live below the poverty line, and many people in these areas are already looking for a job (Nolan, Laura). A way to increase sewage filtration utilization could be done by training people who are looking for work as maintenance workers for these sewage filtration facilities. This would address the underlying issue of non-functional filtration systems. The population of urban slums in India is 104.7 million people (*A Statistical Compendium*). So, job training for maintenance, which includes filter replacement and prevention of residue buildup, can provide a much larger workforce and the training program has a large potential workforce. This program can be led by The World Bank coordinating with other organizations with similar goals. The World Bank has already spent 1.5 billion dollars and has been working with the Indian government by helping run the Swachh Bharat Mission to help ensure that all citizens have access to improved sanitation ("Sanitation"). With the financial aid and experience in the area of water and sanitation, The World Bank could help make this program a success. Also, the government can help contribute to the cost by paying current wastewater workers a higher wage to train community members. Not only is there a humanitarian reason to help support sanitation causes, but it is also economically justifiable for the government to help disadvantaged communities through this program because it will lead to more jobs and address a present need in the infrastructure. The program will be sustainable because of the constant maintenance required for filtration systems, and as the population grows, sanitation becomes more important. This idea is similar to that of President Roosevelt's Works Progress Administration, a federal program that created jobs for the unemployed to help stimulate the country's economy and improve the infrastructure after the economic crash of 1929 ("New Deal - Facts & Summary").

In rural populations, the issue of access to clean water and sanitation is inextricably tied to the issue of water conservation. Rainwater harvesting, the collection of rainwater in a container for later use, can be used to help provide clean water and sanitation. A building containing roof gutters collects water, and the water flows into large container-like structures built in communities. Even though this is already used by some people in India, if it were implanted on a larger scale, this could save thousands of gallons of water. Large scale rainwater harvesting is already in use to address clean water conservation in places like Singapore, Tokyo, Thailand, and Botswana, so this is a plausible idea to implement (*Examples of Rainwater Harvesting*). However, because of the size of these containers and bacterial growth concerns there must be regular maintenance of these systems (*Rainwater Harvesting*). Two other reasons a system like this is hard to implement in a large scale are due to the lack of research on rainwater harvesting and the trade-off between water equity and cost effectiveness. (*Rainwater Harvesting in India*). However, if a significant amount of the water is used for sanitation and agriculture, rainwater harvesting can be cost effective. For example, the water received can be used by community members to flush toilets (water for this purpose doesn't need an expensive filtration process), so feces can be routed into sewage treatment plants instead of to the streets. Also, farmers can use the collected water to help grow crops; water for this purpose only needs basic filtration. This relatively simple filtration process costs significantly less compared to previous large-scale rainwater harvesting systems. Governments already subsidize farmers for growing certain crops, about 18.6 million USD per year, primarily to tackle the issue of water access (Salunkhe). With a lower water conservation cost, farmers can grow these crops at a lower cost. These farmers will thereby be able to allocate a portion of the received subsidy toward the cost of

research/planning and maintenance of rainwater harvesting systems in their communities. Tax revenue from local businesses can also contribute to the cost of paying people to maintain rainwater harvesting, because these filtration systems give people an incentive to stay in the community due to better living conditions and working toilets, thereby maintaining and even increasing patronage at local businesses. Other benefits of a large-scale rainwater harvesting system are that this idea can be implemented by nonprofit organizations due its low marginal cost, especially when multiple stakeholders contribute toward the cost, and that this is a sustainable idea due to the fact that rainwater will always be available to people.

Lastly, India's issue of crop residue burning could be addressed by using crop residue as a fossil fuel. Crops have the potential to be used as biomass, essentially any organic matter used as fuel. This biomass can be turned into synthetic gas and biochar using a process called gasification. These two products can be co-burned to produce electricity and make chemicals which are much more eco-friendly than other sources of fuel (Hiloidhari). As mentioned earlier, 620 million tons of crop residue are burned each year in India. Considering the fact that each ton of biochar made from gasification contains about 600-650 liters of transport fuel, and there is an estimated price of 40 rupees per liter of fuel (0.58 USD/liter of fuel), 620 million tons of crop residue represents a significant amount of lost fuel (*Can Gasification Be the Solution to Crop Burning?*). India already has issues with power cuts due to its high population; using crop residue as a renewable energy source could help decrease the air pollution because the crop would no longer need to be burned. However, in order for this proposal to work, farmers would need to manually till all their crop residue. The tedious nature of the task is the main reason why farmers practice crop residue burning in the first place, but farmers themselves would gain an advantage from the additional energy source that could be used for electricity, creating an incentivize for farmers to till their field and use the crop residue for gasification as an alternate to crop burning. For this strategy to work government and other entities like The World Bank would need to set up gasification systems in areas where farmers practice crop residue burning. Gasification systems work by using little oxygen, steam, and high temperatures to convert biomass into carbon monoxide, carbon dioxide, and hydrogen. The carbon monoxide then interacts with water, in a process called water-gas shift reaction, to create more carbon dioxide and hydrogen. Because plants use carbon dioxide for cellular respiration, the CO2 is essentially recycled and this process has relatively low net carbon emissions (*Hydrogen Production: Biomass Gasification | Department of Energy*). It is in the government's interest to spend the money to create these systems because they already have an unmet goal of reducing crop residue burning. The residue can be bundled and brought to nearby turbines to be gasified. If implemented, this solution would increase both safe drinking water and electricity for rural areas; the solution also has the potential to allow India to be on the forefront of cutting edge technology. Rather than approaching this problem legislatively, it may be more effective to use gasification systems, so farmers are intrinsically motivated to stop crop residue burning.

Implementing rainwater harvesting, improved filtration systems, and biomass-based energy in India could significantly improve the lives of the Indian people in a sustainable and cost-effective way. Although there is no perfect solution to completely rid India of its water sanitation problems, it is necessary to make these financial and technological investments in order to make the first step to approach this complex issue. It is important to address the systemic issues present in India while the country is in a period of robust growth in order to have the resources needed for future growth and well-being for all citizens. Communities would not need to worry about the spread of disease simply because they leave their homes in search of water. Children would not have to miss school because of preventable water borne illnesses. Clean water and sanitation are fundamental rights that everyone should have, rights essential for a

prosperous country.

Advantages and Disadvantages of Rainwater Harvesting - Conserve Energy Future. https://www.conserve-energy-future.com/advantages_disadvantages_rainwater_harvesting.php. Accessed 16 Mar. 2018.

Nagar, Haryana, and Himani. "An Analysis of Agriculture Sector in Indian Economy." *IOSR Journal of Humanities and Social Science*, vol. 19, no. 1, 2014, pp. 47–54. *CrossRef*, doi:10.9790/0837-191104754.

Examples of Rainwater Harvesting and Utilisation Around the World. http://www.unep.or.jp/ietc/publications/urban/urbanenv-2/9.asp. Accessed 20 Mar. 2018.

IANS. "Nearly 70 Percent of Indian Farms Are Very Small, Census Shows." *Business Standard India*, 9 Dec. 2015. *Business Standard*, http://www.business-standard.com/article/news-ians/nearly-70-percent-of-indian-farms-are-very-small-census-shows-115120901080_1.html.

India - Family Life And Family Values. http://family.jrank.org/pages/859/India-Family-Life-Family-Values.html. Accessed 13 Mar. 2018.

"India Water Crisis - Clean Water In India." *Water.Org*, https://water.org/our-impact/india/. Accessed 13 Mar. 2018.

Kharsai. *Dry Times - India's Rural Economy*. https://www.economist.com/news/finance-and-economics/21697870-meagre-rainfall-only-part-problem-indias-farmers-dry-times. Accessed 18 Mar. 2018.

"Lack of Safe Water and Sanitation in Schools Affects Children's Learning – and Their Lives." *UNICEF*, https://www.unicef.org/media/media_53234.html. Accessed 20 Mar. 2018.

Mallapur, Chaitanya. "70% Of Urban India's Sewage Is Untreated." *IndiaSpend-Journalism India |Data Journalism India|Investigative Journalism-IndiaSpend*, 27 Jan. 2016, http://www.indiaspend.com/cover-story/70-of-urban-indias-sewage-is-untreated-54844.

"New Deal - Facts & Summary." *HISTORY.Com*, http://www.history.com/topics/new-deal. Accessed 20 Mar. 2018.

Nolan, Laura. *Slum Definitions in Urban India: Implications for the Measurement of Health Inequalities*. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4746497/. Accessed 18 Mar. 2018.

Partnership for Water Sanitation and Hygiene (WASH) | India | U.S. Agency for International Development. https://www.usaid.gov/india/water-and-sanitation. Accessed 13 Mar. 2018.

Projects : IN Swachh Bharat Mission Support Operation | The World Bank. http://projects.worldbank.org/P153251/?lang=en&tab=overview. Accessed 21 Mar. 2018.

Rainwater Harvesting in India: Some Critical Issues for Basin Planning and Research - AgEcon Search. https://ageconsearch.umn.edu/record/47964?ln=en. Accessed 21 Mar. 2018.

Rainwater.Pdf. http://www.who.int/water_sanitation_health/gdwqrevision/rainwater.pdf. Accessed 16 Mar. 2018.

Ratan, Neel. "These Are the Challenges Faced by India's Urban Poor – and How We Can Solve Them." *World Economic Forum*, https://www.weforum.org/agenda/2016/04/these-are-the-challenges-faced-by-india-s-urban-poor-and-how-we-can-solve-them/. Accessed 13 Mar. 2018.

Salunkhe, Harshal. "The Overview of Government Subsidies to Agriculture Sector in India." *IOSR Journal of Agriculture and Veterinary Science*, vol. 1, no. 5, 2012, pp. 43–47. *CrossRef*, doi:10.9790/2380-0154347.

"Sanitation." *World Bank*, http://www.worldbank.org/en/topic/sanitation. Accessed 20 Mar. 2018.

Shiva, Vandana. "From Seeds of Suicide to Seeds of Hope: Why Are Indian Farmers Committing Suicide and How Can We Stop This Tragedy?" *Huffington Post*, 29 May 2009, https://www.huffingtonpost.com/vandana-shiva/from-seeds-of-suicide-to_b_192419.html.

Slums_in_India_Compendium_English_Version.Pdf. http://www.nbo.nic.in/Images/PDF/Slums_in_India_Compendium_English_Version.pdf. Accessed 18 Mar. 2018.

Smith, Oliver. *Mapped: The World's Most Overcrowded Cities*. https://www.telegraph.co.uk/travel/lists/most-overcrowded-cities-in-the-world/. Accessed 18 Mar. 2018.

State-of-Urban-Water-and-Sanitation-in-India-2017.Pdf. http://indiasanitationcoalition.org/admin/assets/uploads/partneraction/state-of-urban-water-and-

sanitation-in-india-2017.pdf. Accessed 13 Mar. 2018.

The World Factbook — Central Intelligence Agency. https://www.cia.gov/library/publications/the-world-factbook/geos/in.html. Accessed 13 Mar. 2018.