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Peru, Water Scarcity

Peru: Harvesting Atmospheric Water in Coastal Peru

As I stood on one of the many cliffs that overlook the waters of the Pacific Ocean on the outskirts of Lima, Peru, I found it hard to believe that when I turned around, I saw sand dunes and thousands of families living without access to affordable water. Upon entering one of the makeshift homes, I found a family of six boys ranging in age from eight months to eighteen years, a father who is rarely home, and a mother who cannot provide for her children. While working the past two summers in Las Lomas, Peru, located sixteen miles north of Lima, I became acquainted with this family, a typical representative of hundreds of thousands of families struggling to survive in the outskirts of Lima. They are routinely forced to choose between food and water, leaving no hope for education or healthcare. The lack of accessibility to basic necessities, like water, burdens families living in the poverty-stricken outer regions of Lima, Peru; but, fortunately, advances in technology bring solutions to this problem within reach.

Peru is the fifth most populous country in South America with a population of 31.33 million people (Central Intelligence Agency [CIA], 2019). It is divided into three main geographic regions: the coast, the Andes Mountains, and the jungle. Within these three distinct regions, Peru contains twenty-eight out of the thirty-two world climates ("Geography of Peru," n.d.). This diversity of geography and climate leads to a wide range of water availability. The coastal region is an arid desert, receiving only six millimeters of rain a year (Howson, 2015). Water availability is limited to the ocean and rivers. This coastal desert makes up ten percent of the land area of Peru, with 2,414 kilometers of coastline. Although it represents the smallest land percentage of the three regions, the coastal area is home to fifty-five percent of the population ("Geography of Peru," n.d.). Over one third of the total population of Peru lives in the capital city of Lima and the surrounding areas, making it the second most populous desert city in the world after Cairo, Egypt (CIA, 2019; Tegel, 2018).

For a typical family living outside Lima, men will work in the mining industry or as truck drivers. They are often gone for extended periods of time, leaving their wives at home to care for their children and complete household duties. In addition to watching over the house and children, women will typically work as street vendors, selling food and goods (Hudson, 1992). The children have access to free public education from ages five to sixteen, but the quality of this education fluctuates depending on the school attended, and many drop out to enter the workforce and help support their family (Clark, 2015). As defined in 2017 by INEI, the National Institute of Statistics and Information in Peru, an individual living on less than 338 soles per month, about 100 US dollars, is considered to be living in poverty (INEI, 2018). Within this city of 10.39 million people, 1.5 million live in poverty, in homes without running water (CIA, 2019; "Water Crisis," 2018).

The challenge faced in providing water for the metropolitan area of Lima begins with lagging infrastructure. An estimated 150,000 people move into Lima from the surrounding rural regions every year. These individuals are usually impoverished, seeking a better life in the city, but lacking the funds to buy or rent existing shelter. They end up living on unoccupied land in squatter settlements, called pueblos jóvenes (young towns), on the outskirts of Lima (Bajak, 2013). I observed new migrant families cobbling together houses from discarded materials such as wood boards, tin sheeting, and fiberglass panels. A single wire was precariously run from existing electrical sources to the individual home. As more migrants come, these settlements expand up the dry, rugged hills of Lima, positioning families farther and farther away from one essential resource - water.

SEDAPAL, the state-owned water utility company, has not been able to run water to the majority of these settlements for two main reasons. First, the hillside location of these towns increases the difficulty of installing running water because costly pipes and pumps are required to run the water uphill. Secondly, SEDAPAL is not authorized to install water utilities on land for which residents do not have valid documentation of ownership (Tegel, 2018). A large portion of the land in the squatter settlements is not legally owned, and the land is often zoned for agricultural or industrial use, not residential. Applying for rezoning of the land and legal property ownership is an expensive endeavor that the people living in these situations cannot afford.

Since people living on the outskirts of Lima do not have direct access to city water services, they must pay for water to be trucked up to their homes. According to Daniel Klopp, founder and executive director of the non-governmental organization (NGO) Voices4Peru, water is purchased from private companies at a price of one to two dollars for forty gallons of water. It is pumped into large barrels situated on elevated ground or on the roofs of houses so that it can flow downward like running water. Depending on the size of a particular family, one barrel of water will last a maximum of three days. The water is used for cleaning, washing clothes, cooking, bathing, and toileting. However, the water is non-potable. It must be boiled if it is to be used for cooking or drinking, which adds an additional cost. Often this water is collected from ditches and side streams, so not only is it at risk for biological contaminants, but it also contains industrial and agricultural chemicals that cannot be removed by boiling. Moreover, it is not guaranteed that the trucks will make it up all of the hills of Lima every day, forcing families, at times, to go without water.

The most pressing problem with the current system of water delivery for those living in pueblos jóvenes is the price. Klopp notes that it costs approximately twenty-five dollars a month to buy water from the truck service. The average cost of water for middle class residential areas of Lima is eighteen dollars a month and only fourteen dollars a month for those living in an apartment complex. Individuals having to buy water from the truck services end up paying twenty-eight percent more a month for their water than those living in middle class suburbs or apartment complexes. This means that the citizens with the least amount of money must spend the most to access water. The additional seven dollars a month that these households are spending may seem like an insignificant expense, but it is an extra twenty percent of their yearly spending that goes towards paying for water. The added cost that these families are incurring for their water is taking away money that they could be using to buy better food, education, or shelter. An innovative solution to the problem of water scarcity needs to be implemented for the 1.5 million people living in the dry desert hills surrounding Lima ("Water Crisis," 2018).

One way to reduce water scarcity for the impoverished citizens of Lima is to harness atmospheric water. At any one time, 12,900 cubic kilometers or 0.04 percent of all the freshwater on earth is trapped in the atmosphere (Qadir, Jiménez, Farnum, Dodson, & Smakhtin, 2018). Although statistically Lima receives six millimeters of precipitation annually, this is not from rain as we know it. Lima and the surrounding area is under a dense fog for seven months of the year, typically from May to November (FogNet Alliance, 2018). The fog collects as a drizzle, called garúa, which eventually amounts to the yearly precipitation for the region ("Geography of Peru," n.d.). Tapping into this underutilized source of water will reduce water scarcity in the pueblos jóvenes surrounding Lima (Bajak, 2013).

New technological advances make it economically feasible to harvest atmospheric water with a device known as a fog net. Fog nets utilize a vertically suspended mesh stretched in a rectangular metal frame to trap moisture from the air. The water droplets are caught on the mesh and pulled by gravity down into an open gutter along the bottom edge of the mesh, eventually running into a larger pipe system which leads to a reservoir for storage. These systems can range in size from twenty to fifty square meters of mesh surface area and typically produce five liters of water per square meter of mesh surface area a day (FogNet Alliance, 2018). Cost varies depending on the size, quality, and number of fog net systems purchased, but ranges from a few hundred dollars to a few thousand dollars. A forty square meter fog net costs around fifteen hundred dollars to build and will produce an average of two hundred liters of water a day, whereas larger net systems that provide for a village, producing two thousand liters of water a day, cost around fifteen thousand dollars ("Frequently Asked Questions" [FAQ], n.d.). The overall cost is primarily up front for fog net systems as operation and maintenance costs are minimal. These capital expenses are insignificant compared to the costs SEDAPAL would incur if installing pipe and pump systems to deliver water uphill to these communities. In addition, fog nets can be installed in a matter of days. This provides a more rapid solution than laying traditional water infrastructure systems. Fog nets are affordable and easy to install.

Two key factors in maximizing the amount of water a fog net system can produce are the type of mesh used and the positioning of the unit. Current mesh nets are made of either polyethylene or polypropylene. This material can last ten years and costs twenty-five to fifty dollars per square meter (FAQ, n.d.). In recent years, researchers have produced fabrics with a three-dimensional mesh structure, which results in higher efficiency of water collection. Massachusetts Institute of Technology has also conducted research on fog net mesh and found that by putting less space between fibers and coating these fibers in a solution that allows the water droplets to run down the fibers faster, around eight percent more water can be extracted from the air than by standard mesh material (Chandler, 2013). Regardless of the type of mesh used, fog nets need to be oriented properly based on wind direction and the position of other nets within the system. If not correctly positioned, water yield can be adversely affected by up to twenty-five percent (FogNet Alliance, 2018; FAQ, n.d.). A fog net system project in Mejía, Peru found that nets are most productive in coastal Peru if they are oriented to the south in areas of high wind. Southerly winds come off of the ocean and carry with them more humidity and high wind speeds move more air around, which results in more water collected (Project Information, n.d.).

Currently, fog net system use is not widespread and is funded by NGOs. Government-subsidized installation of fog nets could reduce the cost of water for those families living without access to city water infrastructure. SEDAPAL has committed to invest 2.7 billion dollars towards new infrastructure over the coming years. The World Bank is assisting SEDAPAL in this endeavor and has recommended that working at a local level be included in this effort to provide water for all of the citizens of Lima (Howson, 2015). A portion of the infrastructure funding should be designated towards fog net expansion. This would cover three necessary components: 1) site feasibility and net placement studies, 2) capital to purchase and install fog net systems, and 3) subsidies during the dry season for citizens committed to sustainable water systems. Individual communities or NGOs could apply for government funding for a fog net through a grant system. If the site were deemed acceptable and a fog net system were installed, distribution and maintenance responsibilities should shift to the local communities.

The community would begin to reap the benefits of their fog net water collection system even before the first drop of water is collected. NGOs could assist the community in creating systems or cooperatives for distribution and maintenance that foster a sense of ownership and pride in the fog net project (Klemm, O. et al., 2012). Many of the pueblos jóvenes have already created local governing councils. In working to improve their communities, these councils have sought ways to provide access to a more affordable source of clean water. Although the local desire to improve water access is present, most are likely unaware that a locally maintained solution is available (Klopp, 2018).

Citizen motivation and commitment is essential to the long term success of the fog net systems. They need to see the fog nets as an opportunity to not only stabilize, but also improve their economic position. The fog nets serve as a source of water and an investment that could lead to the start of a business. The water produced can be used to supplement water bought from the water trucks, reducing the amount of money community members spend on water every month. The water collected by fog nets can also provide an income in two ways. Any excess water collected can be sold to other families or businesses outside the cooperative for an amount less than that charged by the water companies. Water can also be used to grow crops such as cacti that produce fruit that can be sold (Project Information, n.d.). Fog nets improve citizens' economic condition by reducing spending on water and providing an income. Income from the water or produce sales can support the additional needs of fog net systems. After installation, units only require basic maintenance and cleaning. A portion of the money made should be set aside to pay for repairs and maintenance to the fog net system. Additionally, security and anti-vandalism measures need to be taken to protect the net and the water it collects. When community members directly benefit from the fog net systems, they are more likely to preserve the fog net and the water it collects.

Although fog net systems are a sustainable solution to the water insecurity faced by those living on the outskirts of Lima, they do not offer a year-round solution to the problem. The weather conditions required to produce fog are only present in this area during the winter rainy season, typically from May to November (FogNet Alliance, 2018). This time frame limits the capability of fog nets to be a complete solution to water insecurity. Therefore, a system should be put in place to support families during the dry season, from December to April, when fog nets are not productive. Allowing members of the cooperatives who support and maintain the fog net system to qualify for water expense subsidies would reduce their financial burden during the dry season. A portion of the government funds that could have been spent on the more expensive infrastructure and maintenance should be allocated for these subsidies.

Even with these limitations, fog net systems installed on the Pacific coast of Peru have proven to be successful. A fog net system set up in Mejía, Peru, south of Lima, collected 75,600 liters of water per square meter of mesh surface area in one year. This project was operational from 1995 to 1999. As stated in the project summary, "The area of Mejía has shown in the three and a half years of survey a very good potential for fog water collection. Fog is definitely a water resource that can be used for domestic, agriculture/forestry and ecological purposes." (Project Information, n.d.). When taking into account the productivity of the fog net and the overall foggy days, though the foggy days in Peru are limited to about seven months out of the year, the amount of water that is able to be collected per square meter of netting is higher than in most other countries. Fog nets in Peru are successful. Cooperative income from the selling of the extra water during the rainy season would also diminish the financial burden of purchasing water during the dry season.

The simple yet effective technology of fog nets make them an appropriate solution to water scarcity in Peru. When implementing new ideas in foreign places, it is crucial that the ideas fit with local customs, values, and desires. The simplicity of fog net technology allows these nets to be more easily accepted. Net systems do not require electricity or highly skilled workers and once they are installed, there is no cost except for that of maintenance. In addition, fog nets do not use complex machinery, so operation can be easily taught to the local citizens of each community.

Fog nets are a sustainable improvement to the water crisis on the outskirts of Lima, Peru. The desert climate and sloping terrain inhibit access to both natural and city water sources, forcing millions of families to pay exorbitant prices to have water delivered by truck to their homes. As I experienced firsthand, this added financial burden places families in the situation of sacrificing basic human necessities in order to survive. Government-subsidized installation of fog nets, in partnership with NGOs and local communities, would allow implementation on a wider scale. Harvesting atmospheric water will provide communities with a source of both water and income, reducing the impact of water scarcity on the impoverished citizens of Lima, Peru.

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