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Botswana: Pula! (Let There Be Rain)

Botswana is a landlocked nation of over two million people in Southern Africa. The country is bounded to the south by the Republic of South Africa, on its west by Namibia, and on its east by Zimbabwe. On its northern border, the nation is interestingly part of the "Four Corners of Africa," an intersection along the mighty Zambezi River where Zimbabwe, Zambia, the oddly-shaped Caprivi Strip of Namibia, and Botswana all intersect, a site notable for being the only such quadripoint, or four-way international border, in the world (though if one looks closely, even that distinction comes into question) (Jennings). Botswana occupies 581,730 square kilometers, making it exactly the 50th largest country in the world by area (Central Intelligence Agency). For perspective, that would make it the 3rd largest state in the U.S., a little smaller than Texas and a bit bigger than California ("Botswana Size Comparison"). The country is largely flat, with the exceptions of regions like the Tsodilo Hills in the northwest, which are known for their cultural significance and rock art, and the Tswapong Hills in the east.

Before fully diving into the issues that the Batswana people face in the present-day, getting a grip on what has shaped them historically and geographically is key. The Khoi and San peoples were the first inhabitants of this part of Southern Africa, with their presence dating back to over 70,000 years ago, and around 1,000 years ago, Bantu-speaking groups migrated to the area and developed large states. The majority of the current population, including those who belong to the Tswana and Kalanga ethnic groups, descend from those Bantu peoples, though minorities such as people of European ancestry and the aforementioned San also have sizable numbers. Clashes and crises became common during the 1800s, especially during the Mfecane period, but one major development towards the end of the century was the spread of Christianity as trade grew. It remains the most-practiced religion in the country to this day. Also during that time, the British established a protectorate over this area called Bechuanaland. The protectorate was heavily tied to the Cape Colony (present-day South Africa) and the British South Africa Company, economically and in terms of governance, and after the infamously discriminatory Apartheid system was implemented in South Africa, movements for separation started to gain traction in both regions. A moderate democratic party modeled after Britain's Westminster system was favored, and led by Sir Seretse Khama, they were able to incorporate traditional Tswana ways of governing, gain support of the people, and secure independence in 1966 (South African History Online). That system, a multi-level parliamentary republic with separation of powers in place between the legislative & executive and judicial branches, is altogether headed by the President (in Botswana's case), and as Africa's oldest democracy, it has not disappointed (Central Intelligence Agency). The country is frequently dubbed an "African Success Story," and besides the relative political stability, the other big reason for that moniker is the incredible economic growth Botswana has seen because of diamonds. Quite literally diamonds in the rough, if the

~70% of the country that's covered by the Kalahari Desert is to be characterized as that ("Botswana Tourism Organization"). Since diamond deposits were discovered in the 1970s, several mines have opened, including Jwaneng, the richest diamond mine in the world (Dionne). Approximately 90% of Botswana's export earnings stem from gems or precious metals, with electrical machinery and meat among the other moneymakers.

Due to its positioning within Sub-Saharan Africa and the Southern Hemisphere, Botswana experiences a "semi-arid" climate. Summer lasts from November to March and is characterized by both high temperatures and rain. Very little rainfall occurs outside of those summer months since they coincide with the 'rainy season'. Additionally, due to the geographic conditions previously described, as well as the lack of rivers and natural irrigation, approximately 46% of Botswana is classified as agricultural land, but just 0.6% of the country is estimated to be arable (Central Intelligence Agency). This climate does not set up Botswana with the ideal conditions for crop farming, apparent through how the reliance on the agricultural sector in the nation has markedly decreased since independence and when diamonds were discovered. In 1966, 40% of the GDP and 15% of official jobs were all based in agriculture. 80% of people would reside in rural areas; that statistic, in its traditional sense, is now ~30%. However, going by a classification from the National Center for Biotechnology Information, more than 80% of the country's population is actually rural; that is, they either live on farms or in agro-towns, but not in cities or population centers that employ at least 3⁄4 of their residents in non-agricultural work (Tarver). Though the economy has tried moving on, large numbers of people evidently still fit the mold of small-scale family farmers, and they are a critical part of the population. Looking at the average Motswana family, according to the 2017 Botswana Demographic Survey Report, most do have access to necessities like electricity and clean water, though rural folks, with 35.4% of them having access to electricity for lighting, lag far behind city dwellers, at 85.6%, or urban villagers, at 84.0%, in access in each of those categories. Unsurprisingly, the regular household size varies across different districts and parts of the country, but it averages out nationally at a little more than three people. An interesting trend seen recently is that an increasing number of households are revisiting living as an extended family again, contrasting with the nuclear family structure that had become common with the previous generation. Single-parent households have also become more common (Dintwat). An average Motswana family may be living in a self-built detached home and eating meat-rich traditional dishes like Seswaa or Dikgobe (Tarver). However, again, life is not the same for everyone. Many in the rural areas may grow their own food while many of the urban poor have insufficient access and are malnourished. 52.4% of the population reported that they only ate fruits and vegetables "every once in a while," in direct conflict with the common recommendations on nutritious intake, especially for children ("Botswana Demographic"). The reality is that there is a huge difference in conditions between the wealthy and the poor, even when it comes to basic necessities that no person should be missing.

Understanding the information discussed so far is essential to grasping what Botswana is currently dealing with and what a potential solution may look like. Water stress is an issue plaguing the nation, and the longer it's put off or dealt with inadequately, the more the people

stand to suffer. In 2015, Botswana experienced its worst drought in over 30 years, marked by very little rainfall and a dangerous heatwave. A particularly strong year of the El Niño effect, it ultimately led to a >70% decrease in cultivated land and had devastating effects on livestock farmers ("Botswana Tackles Worst Drought"). Though El Niño is more commonly associated with warmer sea temperatures out in the Pacific Ocean, such climate anomalies can have serious implications for people on the other side of the globe as well. The entire phenomenon wreaked havoc across Southern Africa, starting food crises and depleting the water supply. At the time, an Afrobarometer survey found that only half of Batsanwa thought of climate change as a cause for concern. In retrospect, that drought was just one of the first few big signs that the volatile nature of the Earth's changing climate would be a serious matter. Over the last few years, the nation has repeatedly experienced shocks from increasing climate variability in the form of flash floods, sustained dry spells, and more ("Botswana Drought"). Such events place great pressure on the systems and infrastructures a country has in place, and though Botswana is a continental leader and model for economic development, this is one area it too falls short in. The country's main dams and irrigation sources are concentrated in the north and east, along the Limpopo and Shashe Rivers, which becomes problematic given the fact that much of the population is clustered in the south around the capital Gaborone (Batisani). Additionally, in a country with such a rapidly-growing economy, the need for water cannot be overstated. Not only is it a necessity for sustaining life and healthy sanitation, but it's also a core component of the economic processes that drive the country and their society at every level. Using up the groundwater from boreholes unsustainably is setting the nation on a path towards a bleak future, and couple that with the growing problem of environmental degradation, especially in the Okavango region, an extremely important part of the country's tourism industry, as well as the Limpopo basin, an area crucial to the water supply as previously discussed, due to overgrazing and improper farming methods; it seems as no secret that Botswana needs several different action plans that it can respond to these issues with.

As has been highlighted, the problem at the center of this web is using more water than can be replenished. In response, the government has sought out projects to pump in water via pipelines through the nearby countries of Lesotho and South Africa as part of the Orange-Senqu River Basin of Cooperation and Coordination alliance ("Botswana Is Running Out of Water"). Though this definitely lifts some of the pressure that has been mounting on Botswana in recent years due to the droughts, it's also a risk and it should not be seen as a permanent fix. In the past, transboundary water sharing agreements have resulted in conflict or one nation gaining leverage over another, like with the Nile River between Egypt and Sudan, strife over access to the Syr Darya and Amu Darya Rivers in Central Asia, and China withholding water or "turning off the tap" on the Mekong River, jeopardizing the livelihoods of millions of people in countries downstream ("New Evidence"). Also factoring in how sustainable this solution is long-term, though it is a start, other methods must surely be looked at.

One interesting way to tackle this issue is through the implementation of aquaponics. Described as

> "a combination of aquaculture, which is growing fish and other aquatic animals, and hydroponics, which is growing plants without soil… [aquaponics] uses these two in a symbiotic combination in which plants are fed the aquatic animals' discharge or waste. In return, the vegetables clean the water that goes back to the fish. Along with the fish and their waste, microbes play an important role to the nutrition of the plants. These beneficial bacteria gather in the spaces between the roots of the plant and convert the fish waste and the solids into substances the plants can use to grow. The result is a perfect collaboration between aquaculture and gardening." (North)

Presenting an intriguing crossover between the hydroponic and aquaculture systems, both impressive methods themselves, aquaponic growing techniques could be a powerful way to meet global food needs. With the current conundrum being how to sustain and feed an increasing population, estimated to hit nearly 10 billion by 2050, without exhausting the land and water supply, aquaponics could be extremely beneficial. Encouraged by the Food and Agriculture Organization of the United Nations (FAO) as an alternative technique that should be explored, these methods could be adopted by large-scale planters and family farmers alike. Aquaponics

> "provide many benefits to its users. In comparison to traditional conventional agriculture methods, aquaponics uses only one-sixth of the water to grow up to eight times more food per acre. Due to it being a closed system and the use of the fish waste as fertilizer, it also avoids the issue of chemical runoff. Because aquaponics produces both a vegetable and fish crop, communities that implement the system would also have access to better nutrition. Protein-calorie malnutrition is often the most common form of nutrient deficiency in developing countries, so providing stable sources of fish protein to such at-risk communities could potentially be revolutionary." (Rethman)

Such a productive and valuable system would be key to ensuring food security, especially in the developing world, and would be especially advantageous to a country like Botswana, in which arable land is hard to come by. It is a system that doesn't require soil and is extremely productive even with little space or low amounts of water, so in spite of the country's geographic composition and current natural woes, these aquaponic technologies have incredible potential to succeed and satisfy needs there. They would revitalize the agricultural sector, not only yielding more food for Batswana with less, saving water in a much-needed, sustainable manner, but also increasing the opportunities for people in rural areas tremendously, the majority of whom are women ("Botswana Demographic"). Also, for the many children in Botswana who seek work at young ages, even if illegal, to help their family, this type of farming could be a less harmful option, or even a part of their curriculum that they're educated on at school. If aquaponics continues to be tried more, especially in Botswana, and proves to be a viable option, through such novel ways, development for much of the country could take on a whole new trajectory. With better infrastructure and a more direct supply chain in place, much more would be possible, and many more would be fed. Some barriers to reaching that level of implementation would be the knowledge that's needed to properly perform this type of growing and the high cost to set up the system (FAO). Much of the progress made in developing countries with regards to this technology has been through case studies and nonprofits, and in an interview last year, the acting director of Botswana's Department of Agricultural Research and Horticulturist, Mr Douglas

Machacha, showed optimism about aquaponics and hydroponics and the good they could do to countries in that are in the place of Botswana, seeking to continue developing economically and environmentally at the same time ("Botswana Fish Farming"). The government has shown openness to such progressive change and initiatives in the past, so perhaps even the cost of starting this system could be brought down through subsidies to the point where widespread adoption would truly be possible. The approach of the government subsidizing or providing incentives for farmers and businesses to implement different growing methods, in moderation, is a strategy that is tried and proven, especially in developing countries that are on the verge of rapid change. In a 2019 study concerning the adoption of improved grain storage bags in Uganda, researchers concluded that

> "The main policy implication from this study is that a one-time or short-term subsidy may be an effective tool at spurring demand for a new agricultural technology. In this case, the subsidy creates a positive experiential learning effect that reduces the level of uncertainty associated with the adoption of the technology. Provided there is a persistent learning effect such as demonstrated in Fishman et al.(2017), demand for the technology should be sustained beyond the subsidy intervention." (Omotilewa, et al.)

Many of the world's biggest international bodies also foresee such an approach, built upon fostering innovation and enabling more people to adopt promising technologies, as the basis for any type of sustainable and better future. Both in this exact sector, as well as in other areas that connect directly to a viable society for everyone, such as clean energy and more equitable food distribution, enacting policies that encourage innovation and betterment of their respective infrastructures is a necessary path to take. Botswana can build upon the foundations of water usage that have historically been in place - withdrawal from nonrenewable aquifers and boreholes - as well as some of the newer "Smart Water" and water treatment methods that were put in place to expand potable water access to everyone as the country developed (reverse osmosis, UV water sterilization, etc.), to successfully progress towards the next step, alleviating the stress on the water supply ("Home"). Through the aforementioned approaches, which combine policy and social entrepreneurship, Botswana can constantly adopt new technologies, essay their viability and actual potential in the country when employed, and handle the national supply stressors in novel ways. All throughout this process, creative strategies that build off of feedback, perspectives, and data on solutions tried can be incorporated for maximum success and wide-ranging acceptance by the people, in turn meaning greater support for more initiatives and further government promotion of research and development that benefits all. For example, using citizen science to address grand challenges in these sectors is a fairly recent topic that is being constantly researched and experimented with, and in the words of researchers Michiel Van Oudheusden and Yasuhito Abe, these systems approaches could "potentially reconfigure relations between science and society" (13). The promise that they and many others see in citizen science is how these methods, at their core, are incredibly community-centric and receptive to the inputs of the average citizen, leading to results that are much more holistic and informed. Also, the latest developments in Information and Communication Technologies (ICTs) with respect to these areas, summarized by the Water-Energy-Food Nexus, are just as promising, so continued support and funding for a future with those who will bring these strategies is key (Karpouzoglou, et al.). Perhaps in realization of this, earlier this year, the "Botswana Innovation

Hub (BIH) announced a new funding programme, Grand Challenges Botswana, to support bold and impressive innovations to accelerate progress towards achieving Botswana's national development priorities and economic transformation" ("Grand Challenges Botswana"). With collaboration between and sustained contributions by BIH and other established government sources of funding for this sector, like the Department of Agricultural Research (DAR), and given how Botswana is already regarded as a continental leader in science and technology policies and initiatives, support and funding for the new-age solutions (to these rather new-age problems) - whether aquaponics or any of the many other possibilities that will emerge - should not be an area of concern.

A unique way in which Botswana in particular could utilize aquaponics growing and the opportunities and development that stem from such remarkable system solutions is to more directly involve those with HIV/AIDS. Botswana has one of the highest prevalence rates of the disease in the world, and research has shown the impact food insecurity and malnutrition can have with respect to this virus. Food insecurity has been associated with "increased HIV transmission risk, poor clinic attendance, poor antiretroviral therapy (ART) uptake and adherence, poor immunological and virological responses, lower efficacy of ART, and high mortality," so working towards an integrated opportunity or solution that mitigates this would be incredible ("The Syndemic Threat"). Establishing aquaponics farms, like done by the Immanuel Sheefeni AIDS Foundation in neighboring Namibia, but with many of the jobs allocated for those with HIV/AIDs, would be mutually beneficial; the farm gets people who will help in the group effort for food security and safeguarding a clean water supply, while those with the virus, who are often stigmatized and have trouble finding work due to their condition, would be able to make a direct impact as well (Setlhare).

The nation of Botswana is certainly at a unique spot in its fight for a better future. Developed to a certain extent, but faced now more than ever with problems that truly test its ability to continue along the path of progress. Ensuring the safety of the water supply for later, adjusting to stand strong against abnormalities and volatility in the climate, planning for infrastructure of the future and how to ensure equity and universal access - all of these are things the nations in the world, regardless of where or who they are, must all actively work towards for the greater well-being of the planet as a whole. Aquaponics presents a unique solution that can connect through multiple of these issues, these sustainability goals, and lead to a framework for development that will uplift not only the people directly involved in growing, but everyone around them as well.

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