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## **Cape Verde: Feeding a Country through Sustainable Agricultural Techniques**

### *Introduction*

The country of Cape Verde faces a significant problem. On its glittering surface, with the many tropical islands and sun-bathed beaches, living on the island seems like a paradise. However, because of its attractive beaches, Cape Verde has invested significantly in expanding its tourism industry rather than its agricultural and sustainability industries. Furthermore, its dry climate and lack of rainfall - the very things that make its beaches ideal - make farming quite difficult within the country. Coupled with the lack of arable land, it isn't hard to see why there's a heavy dependence on imports ("Cabo Verde - Trade"), negatively impacting food security. The problem is, even if a country has the financial ability to import food, it does not necessarily translate into receiving the food, as seen during the last major food crisis, when Pakistan and India imposed an embargo on rice (Mbaga). How much worse would it be for third-world countries that lack financial resources? Coupled with supply chain issues from the Ukrainian War and disruptions from COVID-19, food prices have skyrocketed, leaving many of the population unable to obtain food (Mbouet). As a result, Cape Verde must adopt new methods of sustainable agriculture like aquaponics and increase freshwater supply through the use of desalination plants to relieve its dependency on food imports, expand its agricultural industry, and combat food insecurity.

### *Introduce the Country*

Cape Verde is a tropical archipelago off the coast of Senegal with 10 islands. San Tiago, the main island, houses around half of Cape Verde's population of 522,000 inhabitants according to the World Health Organization. Because the island of San Tiago has the majority of the country's population, I will be addressing sustainable solutions to solve problems on this island first. The country's capital city, Praia, is located on San Tiago's southern coast, with modern infrastructure, a strong economy, and an expanding population. Within the city is the University of Cape Verde, which will be critical later on. While the surrounding areas of Praia are quite developed, the landscape becomes more rural the further you move out, with less developed infrastructure and a strong dependence on local agriculture, fishing, and other small businesses. In general, around 44% of Cape Verdans live in rural areas, comprising a substantial amount of the population. In total, around one in every 10 inhabitants suffers from acute food insecurity, amounting to around 46,000 people in Cape Verde. This statistic is due to a lack of natural resources like land and freshwater. Furthermore, while about 80% of the population is employed in some form of agriculture, agriculture only accounts for 12% of the total GDP, and 90% of food is imported. On top of that, the typical family diet in Cape Verde consists mainly of cereals like maize, rice, and wheat, supplemented by some dairy products and meat if they can afford it, which severely lacks nutritional value.

### *Cause of Hunger*

The lack of food accessibility among Cape Verdeans ultimately comes down to their dependence on neighboring countries for food supplies, leaving the country incredibly vulnerable to food shortages and price hikes. A variety of recent factors such as climate shocks, recurrent droughts in recent years, dips in food production, and the disruption of the supply chain due to the COVID-19 pandemic and the Ukrainian War have further exacerbated the country's issue of food accessibility. Such factors listed above increase the cost of importing food, resulting in skyrocketing prices that leave many unable to afford food. In fact, at its peak, one analysis done by March Cadre Harmonisé predicted that over 43,000 Cape Verdeans faced acute food insecurity within the country during the 2023-2024 year, accounting for nearly 10% of its population (WFP). The key to combating such an issue lies in boosting food production through the line of sustainable agricultural practices, making the most of Cape Verde's limited natural resources. While such efforts require the passing down of new knowledge, training, and money, organizations like the UN and the World Food Programme have already implemented policies to promote sustainable development goals. Due to the help of these organizations, knowledge of soil conservation and water techniques has already been spread among Cape Verdeans. However, given the growing population, increasing severity of droughts, and lack of resources, traditional agriculture can only do so much. It is time for Cape Verde to turn to other means, such as aquaponics. By boosting food production through new, innovative agricultural techniques, the urban poor can have much easier access to affordable food. Furthermore, aquaponics completely eliminates the need for fertilizer, benefiting the environment. By transitioning to sustainable methods of agriculture and utilizing the work that has already been started by humanitarian organizations, Cape Verde will be able to effectively utilize its resources to provide food for its growing population.

### *Benefits of Aquaponics*

Aquaponics combines both hydroponics and aquaculture, creating a soilless, symbiotic relationship that mimics nutrient exchanges found in ecosystems (Stone). Aquaponics will especially suit Cape Verde, as its advantages include reduced water and land use, two things that Cape Verde desperately lacks. In fact, aquaponics is so water efficient that "the amount of water required [in aquaponics] is 90-99% less than that of [typical] agriculture" (Mulhern). As Cape Verde's rainfall patterns become increasingly disrupted due to climate change, this transition to a more water-efficient method of farming is critical. Cape Verde also desperately lacks arable land, as mentioned earlier. Aquaponics can fix that. Aquaponic systems can be set up anywhere, as long as the apparatus is in place. Furthermore, aquaponics is well-suited for growing nutritious crops like lettuce, spinach, herbs, tomatoes, cucumbers, beans, and peppers (Elliott). This would make leafy green vegetables more abundant, increasing the local inhabitants' nutrient intake. Those living in Cape Verde often do not have the resources to get their hands on these kinds of foods. As mentioned previously, the diet of the poor in Cape Verde mainly centers around grains and cereals because they are filling, not necessarily because of their nutrient value. Such a trend is mimicked by other developing countries, and their populations are missing out on nutrition as vegetables are abundant in vitamins A, C, E, and K. Furthermore, they also provide high levels of magnesium, fiber, iron, potassium, calcium, and antioxidants that play a crucial role in preventing the development of cancers (USDA). Adequate consumption of these vegetables also promotes digestive health, maintains gut health, and prevents cardiovascular disorders, benefiting the general population by making these healthy foods more widely available. Local farmers and businesses will also benefit from aquaponics. What was once an ailing field, given the lack of natural resources on Cape Verde, can be transformed into something entirely different and profitable. Furthermore, aquaponics will also benefit the environment as it cuts down on the need for fertilizers and pesticides, and reduces the carbon footprint associated with shipping. Due to all these benefits, investments should be made in aquaponic systems as they directly increase Cape Verdeans' food options, nutrient intake, health, and benefit the environment.

### *Cost of Aquaponics*

Now, the upfront cost of commercial aquaponic systems is quite high (Underwood and Dunn) and can act as a major deterrent. To solve this, there are several adaptations we can make to be more cost-effective. For instance, many commercial aquaponic systems come in greenhouses. Expensive structures like greenhouses are not necessary, however, since many of the advantages - natural light, protection, and temperature control - can be mimicked in a much less expensive structure, better suited to the climate of Cape Verde. In fact, given the amount of sunlight and heat Cape Verde receives, greenhouses may be too excessive and trap too much heat inside. To be more cost-conscious, a simple structure with concrete walls on four sides and a transparent roof to allow sunlight in is all that is necessary. While the temperature control and humidity control units will still have to be installed, which may cost some money, the good news is that Cape Verde remains quite warm year-round, which translates to less money spent on electricity used for temperature and humidity control.

	Vegetable		Fish		Total	
Facility component	79,637	46%	26,307	61%	105,944	49%
Labor	30,669	18%	8,917	21%	39,586	18%
Machinery and equipment (rental and fuel cost)	39,983	23%	8,238	19%	48,221	22%
Operational machinery and equipment purchase cost	23,327	13%	-	0%	23,327	11%
Total	173,616	100%	43,462	100%	217,078	100%

*Figure 1: Initial Cost to Build an Aquaponics System from a model aquaponic farm in Hawaii, by Tokunaga et al.*

	Lettuce		Fish		Total	
Labor	29,924	57%	1,918	14%	31,842	48%
Electricity	11,890	23%	3,242	24%	15,132	23%
Water	3,265	6%	890	6%	4,155	6%
Seed and seed bed	1,122	2%	-	0%	1,122	2%
Feed	-	0%	7,216	52%	7,216	11%
Chemicals	1,209	2%	-	0%	1,209	2%
Machinery and equipment fuel cost	3,122	6%	-	0%	3,122	5%
Land rental cost	1,874	4%	511	4%	2,385	4%
<b>Total</b>	<b>52,406</b>	<b>100%</b>	<b>13,777</b>	<b>100%</b>	<b>66,183</b>	<b>100%</b>

*Figure 2: Operational Cost of Maintaining an Aquaponics System*

While aquaponic systems require a significant initial investment, in the long run, they can be expected to raise production and drive down the price of crops (“Economic Feasibility”). In the case of the commercial Hawaiian aquaponic farm used for the case study, it costs around \$217,078 to construct their commercial system in Figure 1. The total operational cost, which was considerably lower than the initial cost at \$69,309, mostly stemmed from labor costs and electricity, and when added up, accounted for 71% of the total operational cost according to Figure 2. As mentioned before, Cape Verde will not require as much electricity because most electricity costs stem from heat and lighting (“Economic Feasibility”), both of which Cape Verde has plenty of. This commercial system generated 89,549 heads of lettuce and 3,360 tilapias for consumption (Tonkuga et al.) With this amount of product produced, the business was able to generate positive cash flow despite competition from other companies with differently sourced foods.

#### *Highlighting Successful Programs (and other Ideas) from Other Countries*

Given that aquaponics will require government incentives and research, scientists must be convinced that aquaponics will reap benefits. Hawaii has already been discussed, and it holds many similarities with Cape Verde: it is also an island, heavily fueled by the tourism industry, and largely dependent on imports (“Hawaii-Economy | Britannica”). With aquaponics gaining traction within the Hawaiian communities, more research and several large-scale aquaponic operations are emerging and have shed positive findings. According to a study administered by the University of Hawaii, commercial aquaponic systems are both feasible economically and profitable (Tokunaga et al.). Another excellent example would be Singapore - also an island - which has recently developed a reputation for spearheading revolutionary, innovative sustainability technology. Such an involvement with sustainable agriculture came from the fact that Singapore used to import over 90% of its food (“The Singapore Aquaculture Plan”), a statistic very similar to Cape Verde’s imports. Recognizing its food dependency, Singapore announced its 30 by 30 goal (producing 30% of food needs by 2030), leading to the implementation of the Agri-food Cluster Transformation fund (Singapore Food Agency). The fund enables farmers to apply for up to \$6 million to

purchase large-scale, advanced commercial farming technology to enhance sustainability and efficiency. Innovative methods such as rooftop farming are also encouraged and introduced, given Singapore's lack of land (Khor). What Singapore lacks in resources, it makes up for with innovative technology. Another great example of this is its aquaculture farms, some of which employ AI to detect and identify the health of the fish as well as their eggs (Singapore Food Agency). Aquaculture comprises about half of the aquaponics system, and advancements in such an area certainly benefit aquaponic technologies as a whole. Lastly, Singapore is also designing a special logo to identify products grown locally (Khor). Coupled with encouragement to buy locally grown foods, the distinct logo enables customers to easily identify products and support local businesses. These are just several ideas that can be adopted by Cape Verde. By looking to other countries that have already started implementing aquaponic farms, the citizens of Cape Verde can follow the examples set and stay confident in the success of aquaponics.

### *Role of the Government and People*

The government of Cape Verde should incentivize farmers and commercial food businesses to experiment with aquaponic systems by subsidizing them. While the government should highly encourage citizens to experiment with aquaponic systems, care must be taken so that not all current food-growing businesses convert to aquaponics all at once. This would result in temporary food shortages and weakened trust in the aquaponic system. Rather, aquaponics should be a supplement to the current food production at first, and the transition can happen gradually. Funds to support start-up commercial aquaponic businesses and smaller-scale systems for local farmers can come from the agreement that was recently signed between the US African Development Foundation (USADF) and the government of Cape Verde, promising 10 million dollars worth of funds over five years to enhance sustainability and agricultural food chains (Press Release). Businesses and local farmers can receive subsidies to cover the initial upfront costs of building an aquaponics system, as well as a little bonus portion as a further incentive. Many may be reluctant to adopt aquaponics because it is a completely different method of farming. Cape Verdeans' way of farming, which may have been passed down over generations and become tradition, will be changed completely. However, they also understand the problems they face with food security, and the little bonus incentive after all the initial upfront costs are covered for their aquaponics system serves as a push. By incentivizing and covering the costs to invest in an aquaponics system, local businesses and individual farmers will be more willing to adopt this new method of farming, changing their way of life.

However, it should not only be the government that is responsible for the implementation of aquaponic systems: the people should play a role too. Ordinary citizens who can afford it should support local aquaponically grown foods to support local businesses. Besides this, just being open-minded to change within their lives and way of farming will also be enormously beneficial. In this way, the people and the government can work together in harmony to further publicize aquaponics. With the people and the government working together, it will be much more efficient to implement aquaponics within Cape Verde.

### *Publicizing Aquaponics*

The University of Cape Verde on the island of San Tiago is a very valuable resource that can be used to introduce aquaponics systems to the public, as it can be the basis for educational campaigns and engraining aquaponics into the culture of Cape Verdeans. The university's mission is to "strategically promote the study and research for the country's sustainable development" (Mendes), which fits perfectly with the mission for Cape Verde to be self-sustainable in food production. The first aquaponics systems can be set up through the university. Later, these systems can also be set up in classrooms and schools around Cape Verde, integrated into the curricula of even middle and elementary schools. Setting up and maintaining a small-scale aquaponics system is quite simple, relatively inexpensive within schools, and is a great hands-on experience for students to see innovative agricultural techniques in action. Demonstrations of how to care for an aquaponics system and even how to set one up can be made,

allowing students to become knowledgeable in this system and integrating this system into their culture, making it the new norm. By first starting with the university and eventually expanding out, the basic concept of aquaponics systems and how to maintain them can be passed on. In addition, committees set up by the university can go around communities, teaching those who are interested how to set up their own systems. This will also increase the number of jobs available and may pique an interest in STEM that many Cape Verdans may not have known about before. By integrating aquaponics into the curriculum of schools, it increases the familiarity of the next generation with these new technologies, increasing the chances that they will adopt them in the future.

### *Alternative Water Sources*

One last problem that needs to be addressed is the lack of reliable rainfall in Cape Verde. Even though aquaponic systems are extremely water-efficient, water can be lost through transpiration and leaks, prompting refills. With the large number of aquaponic systems envisioned, there will be a decent amount of water needed to start and maintain all these systems. The problem is, there has been a decadal, decreasing trend in precipitation since the late 1960s, and according to Greg Jenkins, a meteorologist at Howard University, this pattern will only continue to get worse (Hamilton). Such a claim is backed up by Cape Verde's chief meteorologist, Jose Pimenta Lima, who believes there was much more water back in his childhood than there is currently (Hamilton). As a result, international organizations like the FAO intervened and provided drip irrigation equipment to set up a system, runoff rainwater from the mountains. While these irrigation systems were a huge success for farmers, who saw a 70-105% benefit in income, if the current rainfall trend is set to continue, even these irrigation systems will not be enough to supply drinking water and aquaponic systems.

Cape Verde must turn to alternative ways of sourcing water, such as desalination plants, to decrease its reliance on the increasingly unreliable lack of rainfall. Because the Cape Verde islands are surrounded by seawater, the close proximity to the ocean makes these seawater processing systems ideal. Cape Verde actually recently constructed a new desalination plant, and its effects were powerful. It increased the annual water supply by 883,000 cubic meters yearly and fulfilled the freshwater demand for about 1,200 people (Staff Reporter). Obviously, one processing plant alone is not enough, but by expanding its network of desalination plants, the needs of the people in concentrated urban cities such as Praia, which require enormous freshwater demands, can be met. As the population expands and the freshwater demand increases, Cape Verde should be prepared to invest even more in these projects.

### *Conclusion*

Given the shifting weather patterns and increasing lack of rainfall within Cape Verde, optimization and expansion of traditional farming methods will never prove successful enough to relieve Cape Verde of its dependency on food imports. Combined with the recent price hikes in food supplies due to supply shortages, it is clear that this country must become self-sufficient through innovative agricultural techniques like aquaponics and obtain water through desalination plants. These farming methods are not difficult, and the common people can be taught to maintain these innovative systems, which will finally enable year-round, sustainable food production.

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