Food Production and post COVID-19 Aruban food security

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Abstract

The COVID-19 pandemic affected the world in multiple ways, one of them being the exacerbation of food insecurity worldwide. This paper seeks to find out how the COVID-19 pandemic affected Aruba's food production. Through analyzing existing literature, WFP survey answers from the local population and interviewing local stakeholders. During the brunt of the pandemic, it appeared that the Aruban community had taken matters into their own hands and started producing their own food. The island does not have favorable conditions to grow crops. The intervention of technological applications is necessary to sustainably grow food on the island. In the end it seems that the island's purchasing power is what is maintaining food security.

Keywords: COVID-19, food security, small island states, food production, Aruba.

Table of Contents

Introduction

Small island (developing) states (SIDS) were first recognized by the UN in 1992 at the United Nations Conference on Environment and Development (UNCED) in Barbados (Connell, Lowitt, Saint Ville, & Hickey, 2020). SIDS are a diverse group of countries with size-related problems and needs.

The majority of SIDS are located in the Caribbean and Pacific regions. SIDS are characterized by small size, limited resources, vulnerability to environmental shocks and over-dependence in trade (Connell, Lowitt, Saint Ville, & Hickey, 2020). These characteristics are the very same things that amplify the challenges of achieving the UN's Sustainable Development Goals by 2050.

"Development in SIDS is further affected by high communication, energy and transportation costs, irregular international transport volumes, disproportionately expensive public administration, and scarce physical and skilled human resources that prevent economies of scale," (Connell, Lowitt, Saint Ville, & Hickey, 2020). At the Third International Conference on SIDS assembled by the UN in 2014 in Samoa, food security was identified as a priority area where SIDS are becoming increasingly vulnerable. SIDS are exceptionally hazard-prone due to long coastlines relative to land areas (Connell, Lowitt, Saint Ville, & Hickey, 2020).

SIDS are among the most vulnerable places to be impacted by climate change. Extreme weather events, sea level rise, stressed water resources due to changes in rainfall patterns, intermittent droughts and acidification of the oceans all pose threats to the agricultural and fisheries resources underlying their local food systems (UNFCC, 2007). Food insecurity in SIDS also presents itself in the form of increasing rates of non-communicable diseases such as diabetes, strokes, hypertension and obesity. It also introduces increasing rates of undernourishment. In Latin America and the Caribbean the prevalence of undernourishment was 7.4% in 2019, under the world prevalence of undernourishment but that still translates into millions of people in the regions (FAO, IFAD, UNICEF, WFP and WHO, 2020); (Connell, Lowitt, Saint Ville, & Hickey, 2020).

The COVID-19 pandemic is expected to exacerbate these issues and is also expected to add between 83 and 132 million people to the total number of undernourished people in the world (FAO, IFAD, UNICEF, WFP and WHO, 2020).

As is often the case with SIDS there is very limited research done in local contexts, this is no different for food security. Food systems on SIDS are complex, because multiple factors provide context to case specific situations, such as social context, ecological context or financial context.

More or less, all SIDS have had their food systems impacted by colonialization, decolonialization, trade, transport, migration, urbanization, and the ascent of multiple modernities (Connell, Lowitt, Saint Ville, & Hickey, 2020). While some view globalization as necessary to achieve a free market, globalization has had a negative impact on SIDS' food systems. Increasing trade, mainly imports, have led to a decline and in some cases a complete collapse of export-oriented agriculture (Connell, Lowitt, Saint Ville, & Hickey, 2020). In Aruba's case it had led to a complete collapse, until recently that more agricultural ventures are gaining traction,

however they are not yet at the stage where they can export products. The increase in obesity and diet-related non-communicable diseases is on account of that food imports have become significant and diets have become increasingly predominated by foods high in fat, sugar and salt.

In some SIDS agricultural and fishery exports make up a significant percentage of the total exports, sometimes the entirety. For Aruba this is not the case and has rarely ever been the case. In the past Aruba used to export guano, seabird and/or bat excrement, to be used in fertilizers. This export stopped once more inexpensive fertilizers entered the market.

In several islands' contexts, agricultural work has been disparaged as demeaning and unworthy (Connell J. , 2013), this can certainly be applied to Aruba as well, this topic will be expanded on later in the report. In most SIDS even after a transition from agricultural community that provides its own food to a 'cash economy' (used by Connell et al.) where food imports make up a big share of what is consumed, fishing has remained a substantial local food source (Hickey & Unwin, 2020). Once again Aruba differs from other SIDS, this is due to multiple reasons. Aruba was one of the first islands in the region to transition to a 'cash economy' and therefore was one of the first islands to become overly dependent of imports for food. This transition mainly happened because of the island's first refinery, Lago Oil and Transport Company Ltd. Around this time, the other Caribbean islands still relied on the export of bananas, sugar cane and such products to maintain their economy.

When the refinery began its operations on Aruba in 1929, it drastically changed the island and created its economic pillars for nearly the next one hundred years. The refinery needed many workers, more workers than there were men on the island at that time, this caused a huge influx of immigrants to the island specifically to work at the refinery (Lago and Eagle: the oil industry on Aruba, n.d.). All of this led to a shortage of fishermen on the island (Pauly, Ramdeen, & Ulman, 2015), and is the reason that Aruba's fishing industry is not as developed as other SIDS.

Across many SIDS, the extent and use of traditional environmental knowledge has seen a sharp reduction (Connell, Lowitt, Saint Ville, & Hickey, 2020). Whether the knowledge be on which seasons are best to fish or farm, or which foods will help a community make it through a famine. Resilience is a characteristic of many traditional agricultural systems, but commercialization has gradually eroded the social significance of many traditional crops, as islanders have moved closer to the commercial economy (Connell, Lowitt, Saint Ville, & Hickey, 2020).

In 2015, one hundred and ninety-three UN member states adopted the 2030 Agenda for Sustainable Development Goals (SDGs), or colloquially known as Agenda 2030. SDGs provide a shared blueprint for peace and prosperity for people and the planet, now and into the future (United Nations). At the core of Agenda 2030, 17 SDGs are involved as stated in Appendix A. The SDGs are an immediate call for action by the

UN members to improve health and education, reduce inequality, and spur economic growth, while tackling climate change and working to preserve the oceans and forests (United Nations). At first glance it gives the impression that the SDGs are ordered in such a way that first sixteen goals need to be achieved in order to build up to the last goal, SDG 17: Partnership for the goals. However, the goals cannot be achieved separate from one another. Goals 1, 2 and 3 need progress on goals 13, 14, 15 and 16 to be achieved. Moreover, the goals cannot be achieved by a single country, but have to be achieved in cooperation with other states and NGO's, linking goal 17 to the previously mentioned 7 goals.

Covid-19

Coronavirus 2 (SARS-CoV-2) is a severe acute respiratory disease (Ciotti, et al., 2020). The disease was first discovered in the Hubei province in China. It quickly spread all over the world and caused the Covid Virus Disease 19 pandemic.

The first announced case of COVID-19 on the island was on the 13th of March 2020. Quickly after this schools were closed, international travel was restricted, national curfew was implemented, and a lockdown was put in place. Slightly more than 80% of the island's jobs are directly generated by tourism. With roughly 80% of the population momentarily unemployed, the economy was headed towards a period of stagnation. To prevent this the government of Aruba asked for aid from the Netherlands. Shortly thereafter, to ensure there was enough money to pay civil servants, the government lowered all their salaries for three months. In May the government received another 'soft' loan from the Netherlands, now to inject into the local economy, so employers could pay their employees.

In May as well, almost 23% of households became dependent on food aid programs organized by governmental institutions and NGO's (Boyer, et al., 2020). By the end of May all active cases of COVID-19 on the island had recovered. On July 9th the border was opened to the USA and shortly thereafter to the rest of the world except for Venezuela (Wikipedia Contributors, 2023).

Nearly 10% of the population was infected with the COVID virus. In 2021 already, researchers identified a residual illness called Long Covid. Long Covid is a chronic condition that occurs after having been exposed to the COVID virus, and includes symptoms such as fatigue, coughs, myalgia, difficulty to focus, etc (Raveendran, Jayadevan, & Sashidharan, 2021). Yet the bureau of statistics has not released a study on how the pandemic has affected the Aruban society.

During the lockdown the real GDP experienced negative growth, nearly -45% (Centrale Bank van Aruba, 2024). In 2021 the local economy experienced nearly a 50% GDP growth. Since then, the GDP growth has been stable. While the GDP is positive, this does not reflect on the citizens themselves. From the monthly reports of CBS Aruba, an increase in the minimum subsistence level can be observed. From Afl. 5,030.00 in February 2020 to Afl. 5,393.00 in February 2023, to maintain a family

consisting of two adults and two children. And an increase from the Afl. 2,395.00 to Afl. 2568,00 for a single adult in the same period (CBS Aruba, 2023). There is an increase in living costs and GDP, but no significant increase in wages. The minimum wage as of January 1st 2023 is Afl. 1,893.40 per month.

Aruba and food security

Food security was first defined in the World Food Summit in 1996, as follows "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (Food and Agriculture Organization, 2006).

Food security is closely related to SDG2: Zero hunger, it can be argued that it is the foundation for the goal.

Achieving food security is a much more complex problem for Small Island (Developing) States (SIDS) than for continental countries. SIDS as a whole face unique problems that continental countries do not. As the name implies, SIDS are islands, isolated by the sea. Some more isolated than others. This complicates the transport of food, as it has to arrive on the islands by ship or airfreight, both of which add to the final price of the product that the consumer will be paying.

The island closest to Aruba is Curacao, which is nearly 108 kilometers away (DistanceFromTo.net, n.d.). However, the nearest landmass is the Venezuelan peninsula, which is approximately 24 kilometers away (Davila, 2019). In the past the Aruban food network took advantage of this relatively short distance and there were no shortages of fresh fruits and vegetables at moderate prices. In recent years it has become increasingly difficult to take advantage of the short distance. Due to the political instability in Venezuela, fewer Venezuelan ships with food have been coming to Aruba.

In 2020 after the COVID-19 lockdowns had ended, the prime minister of Aruba opened the islands borders for all countries, except Venezuela. This has also impacted food prices on the island, especially the final prices of fresh produce, as they now have to travel longer distances to arrive on Aruba. Fresh produce is now coming from other Caribbean islands or South American countries that are farther away than Venezuela. As Aruba is part of the Kingdom of the Netherlands, it cannot be a member state or associate of CARICOM, therefore it does not get special tariffs on exported items as the other Caribbean countries do.

Another characteristic of SIDS is that they are small in land space. Aruba is a very small island, with an area of approximately 180 km^2 (Boyer, et al., 2020). Aruba had 112,206 persons officially registered as of September 30th 2022, in the Population Registry Office (Central Bureau of Statistics Aruba, 2022). That's more than a hundred thousand people that need housing. So, it stands to reason that the majority of the island has already been covered by urban sprawl. This urban sprawl

leaves very limited space for traditional agriculture and farming. Even if small farms manage to open, they face other problems that are unique to small islands.

Aruba has a small scale and homogenous local food production sector. Currently, 500,000 lettuce heads are produced yearly on the island (2023). Additionally, there is local production of other food products, however they are not yet at a stage in their production where they can give concrete data about their production. As the local food production is still in such limited scale, it is only logical that the islands food needs are met with food imports. Last calendar year, Aruba imported Afl. 708,306,257 worth of food (Centrale Bureau of Statistics Aruba, 2022). Meat and edible meat offal imports alone are 15% of the total food imports. Food on the island is most prominently imported from North and South America, followed by Europe. Food is mainly imported by sea transport (Central Bureau of Statistics Aruba, 2022).

As mentioned in the introduction, a third of all SIDS are located in the Caribbean region (United Nations, n.d.). This makes them vulnerable to yearly tropical storms of various magnitudes. Aruba is fortunate enough to be geographically south of the hurricane belt, a spot where it is not affected as harshly by hurricanes and tropical storms as the neighboring islands. This does not mean that Aruba is not affected at all by these extreme weather events. There have been times recorded in the past when the island has suffered damages from hurricanes and tropical storms (Boyer, et al., 2020).

Aruba faces an additional issue compared to many of the nearby SIDS in the Caribbean as it no longer has a fresh water source. In the early 20th century, fresh water from small aquifers on Aruba was intensely exploited (Derix, 2016). Nowadays, the tap water on Aruba goes through the process of reverse osmosis at the Water and Electricity plant (WEB Aruba). The reverse osmosis process is currently powered by heavy fuel oil to process the saline water into drinkable water. On a similar note, more than 50% of the island's electricity consumption is also powered by heavy fuel oil. This makes potable water and electricity expensive on the island. In the past rainwater used to be collected in "tanki's" during the wet season to have enough potable water during the dry season.

Being a tropical island, it is natural to expect that Aruba has high precipitation numbers, between 1000mm and 2000mm of rain, like other tropical regions. However, this does not apply, and Aruba is prone to droughts. The average rainfall on Aruba is on the lower side for the tropics, 450mm/year (Boyer, et al., 2020). Climate change has affected Aruba's normal rain seasons (Departamento Meteorologico Aruba, n.d.). Aruba's wet season usually corresponds with the Caribbean's hurricane season, from June to early December. In 2023, Aruba was still experiencing frequent rainfall in late January. Aruba also differs from other tropical regions by showing little variation in daily temperature (Derix, 2016). In tropical regions it is common for in a single day there to be an average difference >10° C between the highest and lowest temperature of the day. The temperature fluctuates

between 27° C in the colder months and 30° C during the hot summer months, the average temperature on the island is 28°- 29° C (Derix, 2016).

Given Aruba's volcanic origins and how the island remained millions of years under sea, the topsoil layer is not arable or fertile for growing crops. The soil on the island is mainly composed of limestone and quartz rock

Problem

A simple stroll through a supermarket in Aruba can leave many perplexed. Aruba has a small-scale food production industry; therefore, it stands to reason that food products should not be readily available both physically and economically. Yet that is not the case. Aruba's supermarkets are almost always fully stocked with a variety of food products in all price ranges and in all categories. During the COVID-19 lockdown this did not change, while food prices worldwide went up the Aruban population still had both physical and economical access to it (Boyer, et al., 2020). With the current local production Aruba should be more food insecure than it actually is.

Aruba has minimal and a limited variety of local food production, virtually all food on the island is imported. Covid-19 brought food security to the forefront of the country's priorities. With this thesis, we hope to find ways to alleviate the food insecurity prevalent on the island, through technology and improving the cultural food production methods.

Relevance of study

The extended name of SDG 2: Zero Hunger is "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations, n.d.). As of 2020 the world was not on track to achieve SDG 2 by 2030 (FAO, IFAD, UNICEF, WFP and WHO, 2020). This will obviously impact the whole world, but this report will focus on the impacts it can have on Aruba and how to reinforce the current food network.

Research question

This thesis primarily focuses on the possibility for food security in a post COVID-19 pandemic Aruba. This will be achieved by finding the answers to the following questions:

1. How much food is produced in one year post the COVID-19 pandemic on Aruba?
2. What are the biggest obstacles for local producers on all scales?

3. What technological applications are viable to maximize food production on Aruba?

Hypothesis

The expected results for this report were that the pandemic actually had a positive impact on the local food production. During the COVID-19 pandemic lockdown the majority of the population was forced to stay home. Many people experienced a sense of solace growing their own food due to losing control of their everyday lives (Dooley, 2022). It is expected that this sense of control was run into by the Aruban population. Additionally, spiking food prices worldwide caused by disruptions of the supply chains due to COVID-19 had worsened food security overall. Consequently, the pandemic situation led the population to become more conscious of their own food and have caused them to want to take action in securing their own food.

The goal of this report is to study the effect the COVID-19 pandemic had on the local food production and the possibilities to achieve future food security in Aruba.

Research & Methodology

The research was done through a combination of correlational and descriptive research. A literature review was conducted on the relevant topics that play a role in food security on small islands, such as what is food security, how the cost of food affects food security, who is growing the food we eat and how technology and engineering plays a role in food security. As per the requirement of the degree, the research had to be done with a local context. Interviews with local food producers were conducted. The stakeholders were asked questions along the lines of how big their productions are, what they produce, what challenges they faced and who their customer base was. The answers were analyzed based on common findings between stakeholders. Furthermore, the stakeholders were separated into three categories. The differentiation will be explained later in the paper. One stakeholder was interviewed that does not fit into any of the categories, this stakeholder was analyzed on separate criteria. Additional data about the local context of COVID-19 was collected from the World Food Program Survey in collaboration with CARICOM done in 2022. The fieldwork took place from March 2022 to February 2023. As the interviews were qualitative, no transcription is necessary to meet the ethical requirements.

Literature Review & Theoretical Model

Food Security

As previously mentioned, food security was first defined at the World Food Summit in 1996. In the same brief FAO expands the definition of food security by adding the definitions of the food security dimensions. There are four food security dimensions; availability, access, utilization and stability (Food and Agriculture Organization, 2006). Food availability refers to the availability of sufficient food of appropriate quality. Food access means that individuals have adequate resources to acquire appropriate foods for nutritious diets. Food utilization touches on the use of food through adequate diet, clean water, sanitization and health care to reach a state of nutritional well-being where all physiological needs are met. Finally, food stability calls attention to the need for there to be access adequate food at all times to all levels of society. There should not be a risk of losing access to food due to economic, political or climatic crisis (Food and Agriculture Organization, 2006).

Food availability goes hand in hand with current food demands. Food demands is driven by an increase in total population, urbanization and increase of per capita incomes (Grafton, Daugbjerg, & Qureshi, 2015). Increase in income while having many positive side effects, also has the side effect of affecting people's diets and the food they consume. Often this means an increase in meat consumption.

To keep up with the demand, it is required for agricultural food production to increase farm yields and total factor productivity. The only way to achieve this would be to invest in research on agricultural technology and plant genomics. Moreover, just research is also not sufficient. Increasing food availability without thinking on to maintain a sustainable supply of adequate quality foods, without compromising the ability of food to be obtained in the same way in the future, is no longer a viable solution.

The dimension of stability overlaps with availability, access and utilization (Leroy, Ruel, Frongillo, Harris, & Ballard, 2015). When food stability is threatened it trickles down to the other dimensions, often in the form of increased prices, scarcity of certain products and increased fear of becoming food insecure.

As of 2022 the world was not on track to achieving food security by 2050. Regarding the four dimensions of food security, Aruba struggles with access and stability.

Cost of food

Living costs have become expensive, and the cost of food is not helping. Rising food prices affected 47% of countries in 2020 (United Nations, 2022). Aruba was most definitely a part the 47%. In a World Bank Study for the government of Aruba, 76% of respondents reported to have perceived that food prices had increased in 2020 (Boyer, et al., 2020). The CARICOM and World Food Project survey of 2022 also demonstrated this with 77% of Aruban respondents reporting that food prices had increased in the past two weeks. From the same survey, 84% of Aruban respondents added that they had changed their shopping behavior compared to before the COVID-19 pandemic. This makes it clear that the pandemic negatively impacted Arubans and their ability the economically access food. With mass vaccines roll-out

and business as usual policies set by governments worldwide, why is it that the prices of food have not stabilized and gone back to pre-pandemic equivalents. From June 2019 to December in the same year, local food prices had been stabilizing and ever so slightly going down, then around December 2019 there was a spike (Boyer, et al., 2020).

The most straightforward way of illustrating the increase in food prices on the island, is to use the data provided by CBS Aruba. Every month CBS issues a press release comparing consumer index prices (CPI) to the previous month, the same month one year ago and the accumulate. The CPI measures the changes in purchasing power of the country's currency (CFI Team, n.d.), on Aruba it consists of 408 good and services. The base period was established on June 2019. February 2020 was chosen as the starting point of the comparisons, to get a good overview of food prices before and after the COVID-19 lockdown, furthermore the fruit index is focused on as fruit prices on the island have the tendency to be volatile. By February of 2020, the fruit index had undergone an increase of 3.0% compared to the previous month, and an increase of 31.3% compared to February 2019 (CBS Aruba, 2020). In February 2021 the fruit index had an increase of 1.5% compared to the previous month, however it did experience a decrease of 3.9% compared to February 2020. In February 2022 the fruit index again had the highest increase in the food and catering services category, with a 2.8% increase compared to the previous month and a 12.2% increase compared to February 2021. In February 2023 the fruit index was once again one of the more significant increases with 1.7% compared to the previous month, and a 3.3% increase compared to February 2022. Like fruit most other indices have steadily increased as well.

Even items on the national basic basket as per AB 1991 no.GT 17, have experienced price increases. Rice along with coffee and tea are items with controlled prices, and even these items have experienced subtle increases in prices in between February 2020 to February 2023. From February 2022 to February 2023 the price of rise had risen 35.6%.

The rising food costs are not due to a singular event, but more the combination of several world and economic events. The Ukraine war is cited as a reason for increasing food shortages since 2022. Prior to the war, Ukraine and the Russian federation supplied 30% of wheat and 20% of maize to the global export economy (United Nations, 2022). Due to the starting war, in March 2022 global food prices were 30% higher than the previous year. The countries most affected by the disruption of supply chains were the world's poorest countries and import dependent countries. It is projected that the continuation of the war will add another 47 million people to the part of the population that faces acute hunger (Abay, et al., 2023). Aruba was projected to experience a high risk of food price increases the months following the start of the war.

Women and Food

Nearly 53% of the population of Aruba are women (Central Bureau of Statistics Aruba, 2022), which aligns with World Bank data on the distribution by sex of the global population. According to CBS data, women and men score almost equally in literacy rate, level of education and economic participation (CBS Aruba, 2012). And still, women were disproportionately affected by the COVID-19 pandemic (Boyer, et al., 2020).

The pandemic heavily affected Aruba's economy, it abruptly stopped tourism, which amounts to 84.3% of all jobs on the island. When NGO's were giving help in the form of food assistance, 69% of the recipients were women (Boyer, et al., 2020). Once more Aruba does not deviate from the norm, as globally women appear to have been more impacted than men by the pandemic. At global level, women are more prone to severe food insecurity than men, this trend is not recent or due to the pandemic, the gender gap in accessing food increased from 2018 to 2019 (FAO, IFAD, UNICEF, WFP and WHO, 2020).

This would seem at odds with the fact that regardless that women are more severely food insecure than men globally, women still have higher rates of obesity than men in small islands (Hickey & Unwin, 2020). This would bring us back to the dimensions of food mentioned in the introduction. The higher rates of obesity in women despite being the more food insecure group touches upon the food dimension of utilization. The utilization dimension commonly deals with the nutrients in food and how they interact with bodies (World Bank, n.d.). If women are more susceptible to food insecurity than men and still experience higher rates of obesity, it is not without reason to say that the food they are eating is less nutritious and is probably high in salts and fats. That small island women are affected by obesity can most likely be attributed to a lack of local food production (which accounts increased imported food), colonialism and that 'bad foods' are more often than not cheaper than 'healthy foods'.

Overweight and obesity are also a health concern for Aruba, 36% of adults are overweight and 41% are obese (Aruba, 2019). Even though women are disproportionately more negatively affected than men when it comes to food, they still make up 52% of the agricultural workforce in SIDS (Hickey & Unwin, 2020).

The 2020 The State of Food Security and Nutrition in the World report alludes that women participating in economic activities, such as having jobs, is one of the factors that is driving up the costs of nutritious food (FAO, IFAD, UNICEF, WFP and WHO, 2020). While women have historically been the ones tasked with preparing the food for their families, it is important to realize that companies and governments have driven the cost of living so high up that single income households no longer can afford it, thus forcing women to join the workforce. Women participating in economic activities is something positive because it means they are no longer fully dependent on someone else and actively working on achieving SDG 5. In light of the

fact that women are the ones behind most of the production of small farms, where most of the food that is not used for cattle or fuel comes from, FAO is encouraging women by giving them better access to technology that can help them and teaching them better agricultural skills (Hickey & Unwin, 2020).

On a surface level, Aruba appears to be an outlier when it comes to women in food production. As was found during the interviews with the local food producers, food production is a man dominated field on Aruba with only a few women participating. However, this is not the case and instead is due to a misunderstanding and uncredited work. Women have done uncredited work for a very long time, as demonstrated by McMurry in 1992. According to a census report between 1800-1930 not a single person reported practicing the occupation of dairymaid, yet in the nineteenth century thousands of women were producing tons of cheese and butter (McMurry, 1992). Not much has changed since then until now. At the heigh of the pandemic and its aftermath, women managers in the office were reported to have been doing what has been coined as 'invisible work' (Cooper, 2021). Meaning that women took on the unpaid taxing job of emotionally supporting the employees, often at the cost of they themselves feeling burnt out. At the Aruba Aloe museum, it is stated that women and girls also played a role in the family's aloe harvesting and preparation processes, yet it is always a man in the promotional pictures.

Better farming

As the world population keeps growing (The World Bank, n.d.), it is imperative to explore new ways to keep up with food demand.

One way to produce more food in the shrinking available space, is to produce foods more efficiently. Foods can be produced more efficiently by genetically enhancing crops or making farming more efficient. Worldwide there are a multitude of technological interventions that have made farming more efficient. However, applying those technological interventions without proper research and without definite aim, can have the opposite of the desired effect and ultimately be needlessly costly. To yield positive results, technological interventions must be appropriate for the local- climate, space and natural resources. For technological interventions to be effective in Aruba they must be adequate to the warm climate and high humidity, use space as efficiently as possible, be efficient with water as it is one of the islands biggest constraints and is expected that all water resources will be strained by 2050 (O'Connor & Mehta, 2016), and it must be compatible with local crops.

Figure 1 Greenhouse at Cunucu Fresh

1) Greenhouses in combination with drip irrigation systems
   Greenhouses are buildings designed for the protection of tender or out-of-season plants against excessive cold or heat (Britannica, T. Editors of Encyclopedia, n.d.). In contrast to traditional open air farming greenhouses provide year-round crop growth and reduce water loss (O'Connor & Mehta, 2016). In an evaluation done in Mozambique comparing greenhouses to open-air farming, they had the following results. Certain areas of Mozambique have a similar climate to Aruba in their dry seasons, mainly the capital, with double the rain. The average temperature is 22-31°C, the weather is hot and humid, with an average of 74% humidity.

   I. Plants lose less water through evapotranspiration, due to decreased wind, increased humidity, and regulated temperature in the greenhouse environment.
      The evapotranspiration water loss rate was calculated using the Penman-Monteith equation. See Appendix F for further explanation.

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} U(e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$

      In the study in Mozambique the reference evapotranspiration from inside the greenhouses was compared to the open air in the dry season, as to not

have rain tamper with the results. Due to limited resources only the temperature, wind speed and relative humidity were taken into account. The conclusion was that greenhouses in Mozambique have the potential to save 56.1% evapotranspiration of water.

II. Drip irrigation systems improve the efficiency of water usage
Adding drip irrigation systems to greenhouses can be beneficial as this increases the water savings. Drip irrigations systems allow for precise application of water that targets the crops root zone. Precise water application in a greenhouse can reduce water usage 30-50% compared to open air farming (O'Connor & Mehta, 2016).

III. Closely spaced crops reduce water wastage
Greenhouses can support denser crop arrangements than an open-air plot of similar size. Due to the sunlight diffusion greenhouses offer, evenly distributed and sufficient sunlight is obtained even by closer spaced crops. Furthermore, greenhouses are a physical barrier between air-borne pests and crops, therefore reducing the risks closer crop spacing. Closer crop spacing also optimizes yields compared to open-air pots. Closely spaced crops have denser root zones, thus increasing water productivity by lowering the chances of water going to the non-root zones.

IV. The crop cycle in a greenhouse is typically shorter than in the open-air
Greenhouses have been shown to reduce the length of a typical crop cycle. This reduced crop cycles are a result of the greenhouse's regulated microclimate and its ability to diffuse sunlight to all part of growing plants, which increases the amount of sunlight that each plant receives every day and accelerates plant growth (O'Connor & Mehta, 2016). The reduced crop cycle in greenhouses is not well documented in agricultural literature, however firsthand experience from greenhouse farmers does support reduction in length of crop cycles.

2) Solar irrigation system

Solar powered irrigation systems (SPIS) are a sustainable alternative to traditional water pumps. Traditional water irrigation systems, use fossil fuels to power the pumps, whereas solar powered irrigation systems use solar energy for water pumping consequently reducing greenhouse gas emissions (Schnetzer & Pluschke, 2017). The SPIS that are employed in most places, draw their water from underground sources. This would seem like it would be an obstacle in implementing them in Aruba, as Aruba no longer has any aquafers (Derix, 2016). However, they are still viable for people who use waste water and water from the 'dams' around Aruba as their primary source for watering their crops. There are many benefits to using SPIS, such as they emit no GHG when pumping water, and when life cycle assessment was done on SPIS taking account the emissions from cradle-to-grave they still emitted less GHG than fossil fuel powered irrigation systems (Solar Powered

Irrigation Systems (SPIS) - Technology, Econmy, Impacts., 2016). SPIS promote energy independence, as they do not need to be connected to the energy grid, potentially lowering energy costs. With SPIS people have access to water even during the dry season. There are certain drawbacks to SPIS, over-exploitation of water resources being the biggest stumbling block. However, with adequate legislation and proper water management this is an obstacle that can be overcome.

3) Moisture sensors for optimal irrigation
   Food security is threatened whenever efficient management actions are not exerted to maintain agricultural production (Shamshiri, Balasundram, Kaviani Rad, Sultan, & Hameed, 2022). 25-30% of fresh water is wasted during irrigation processes. Therefore, it is important to practice adequate water management. Optimizing water irrigation is good way to start. Soil moisture sensors can help improve irrigation.
   Soil conditions are influenced by the weather, crop density, crop pattern, etc. (Calderone, 2019). Soil conditions across a field are inconsistent. Sensors can pick up these inconsistencies and give farmers real time data about the soil. Soil moisture sensors measure the dielectric constant of the soil to get an estimate volume of water available in the soil. Water in soil is important because it acts as a carries of food nutrients needed for plant growth (Calderone, 2019). Soil moisture sensors are available in a big price range. Easy to use and inexpensive sensors are available, however these models have troubles with their accuracy and efficiency. Sometimes the sensor hardware itself is not what is expensive, but the calibration is. There are types of sensors while inexpensive, need to be calibrated before use to give accurate results. As a consequence, farmers are less inclined to purchase sensors (Shamshiri, Balasundram, Kaviani Rad, Sultan, & Hameed, 2022).

4) Buried diffusers
   Buried diffusers are also a good start of adequate water management practices. Buried diffusers are an underground irrigation device designed for trees, shrubs and vegetables, saving water and ensuring year-round irrigation of the plants during drought, by supplying water directly to the roots of the plants (Engineering for Change, n.d.). The sub-surface irrigation method is a water saving technology capable of applying small amounts of water directly to the plant root zone where the water is needed, these small amounts can be applied frequently to maintain favorable moisture conditions in the root zone (Al-marri, et al., 2018). Research concluded that buried diffusers provide better plant growing conditions in the early stages of plants growth (Al-marri, et al., 2018). Subsequently, irrigation through buried diffusers is comparable to surface drip irrigation, enough to be thought of as an option to replace it, as

they provide continuous water without much water loss (Al-marri, Elsharied Abdalla, Abubaker, Moussa, & Hichem, 2020).

5) Aquaponics

Aquaponics are a combination of hydroponics and aquaculture, they combine the production of plants and animals, integrate the nutrient flow by natural biological cycles and make the most efficient use of nonrenewable resources (Tyson, Treadwell, & Simonne, 2011). Fish produce ammonia (NH_3) as a byproduct of their natural processes. Ammonia produced by the fish in aquaculture ionizes in water into ammonium (NH_4^+), nitrifying bacteria in the biofilters also converts ammonia into nitrate (NH_3^-). Plants can absorb nitrate and ammonium, as nitrogen is the nutrient required in the largest amounts by plants and nitrate is the preferred way of absorbing it (Tyson, Treadwell, & Simonne, 2011). Depending on the weather the species of fish used for aquaponics changes. For fairer and warmer climates, tilapia is most commonly used. For colder climates cod or trout are more commonly cultivated (Brooke, 2018). Each species of fish has its drawbacks, as a lot of fish turn carnivorous when they get bigger, it is a matter of weighing the advantages against the disadvantages. For Aruba, tilapia would be the best option in aquaponics as this species of fish have a fast growth rate, are tasty, do not require a lot of dissolved oxygen in their water and reproduce quickly. They also do not need a lot of area, which is very convenient as Aruba has limited land space available for use. The initial cost of aquaponic systems depend on the area the system is going to cover, the complexity of the system, the cost of transportation and the labor (Roa, 2023). Depending on if the system is bought premanufactured or will be constructed by the user, the cost can vary significantly. The price range of pre-made systems can start near $6000.00 and go up to and over $100000.00. For an Aruban setting it would be more convenient and economical for the users to make and install the systems themselves. Santa Rosa Aruba offers guidance for the community on aquaponic systems and which materials and crops and fish would be best together. Santa Rosa also promotes the use of recycled or old materials to be more sustainable when building systems. The operating costs of the systems mainly depend on fish feed, electricity costs, maintenance and repairs (Roa, 2023). The main advantage of aquaponic systems compared to traditional farming and hydroponic systems, is that the user can harvest both fish and vegetables from the same labor.

6) Hydroponics

Hydroponics, similar to the previously mentioned aquaponics, is a method to cultivate plants without soil (Aires, 2018). Whereas in traditional agriculture the soil disperses the nutrients the plants need, in hydroponic systems the roots extract the required minerals from a nutrient solution (Velazquez-

Gonzalez, Garcia-Garcia, Ventura-Zapata, Barceinas-Sanchez, & Sosa-Savedra, 2022). There are six main types of hydroponic systems: deep water culture, drip system, aeroponics, nutrient film technique, ebb and flow and aquaponics. All the different types operate by the same principles of not using soil and using a manmade nutrient solution to help the plants grow, whether the roots are in the air, in a growing medium or inside the nutrient solution makes no difference. Hydroponic systems commonly consist of a growing medium, pumps (water or air), a solution tank and sensors. Hydroponic systems are also often kept inside greenhouses to have full control of the environment.

Using a hydroponic system to grow plants has benefits and drawbacks. The most obvious benefit is that arable soil is not necessary. As urbanization and farming compete for land use, the opportunity to grow plants without having to compete for land becomes a very enticing one. Moreover, hydroponic systems can also be placed vertically, becoming even more space efficient. Another important benefit is that hydroponically grown plants grow up to 20% faster than plants grown in soil and have a 25% higher yield (Epic Gardening, 2024). In the same vein, plants grown using hydroponic systems no longer depend on the weather and/or seasons. Finally, plants and produce grown in hydroponic environments are of the same quality as their traditionally grown counterparts. The drawbacks of hydroponic systems are the high initial costs, the necessity of technical knowledge and efficient electrical systems, and knowledge on the crops requirements (Aires, 2018). Not all plants can grow in hydroponic systems, they have to meet certain criteria i.e root size, fruit size, harvesting time cycle (Velazquez-Gonzalez, Garcia-Garcia, Ventura-Zapata, Barceinas-Sanchez, & Sosa-Savedra, 2022). The most popular type of plants grown hydroponically are leafy greens, such as lettuces and water cress. Bulb-, root-, tuber-, stem-, inflorescent-, fruit- and pulse vegetables are also suitable for this type of horticulture.

Hydroponic produce is already being grown and sold on the island. By using the system, vendors no longer have to worry about soil quality. Although, they do have to compensate for the islands' warm weather by using chillers to cool down the water and build greenhouses to limit the amount of direct sunlight the plants get.

7) Back to old farming practices

To increase the yield of specific crops, they are often planted in monoculture. This in turn leads to the crops having no natural defense that other plants provide. Which in turn leads to the use of pesticides and insecticides in traditional farming. This method of farming was popularized by the Green Revolution after the second world war (Antonelli, 2023). Growing in monoculture can have unsustainable environmental impacts such as building up disease pressure and reducing particular nutrients in the soil (Salaheen &

Biswas, 2019). The pesticides used in the fields can leak into nearby bodies of water, polluting them and turning them unfit to drink from. Due to decades of monoculture being the prevailing method in farming, crops face many challenges. Plants have become less resistant to pests and disease, and crops are facing the ramifications of climate change (Antonelli, 2023). It could be beneficial to take a step back and learn from indigenous farming practices. Indigenous communities have been farming land for centuries in a resilient and sustainable manner (Antonelli, 2023). By planting crops surrounded by herbs that naturally ward off insects, it lessens the need for insecticides. Rotating crops from year to year improves soil health and quality (Salaheen & Biswas, 2019). Furthermore, studies have been conducted to study the relationship between weeds and crop yields. Weeds themselves are not intrinsically beneficial to crops. However, they provide resources that help maintain populations of beneficial insects, pollinators (Kleiman, Koptur, & Jayachandran, 2021). Pollinators increase the size, quality and stability of yields (Kleiman, Koptur, & Jayachandran, 2021). The mean number of harvested fruit of mango trees that received the weedy treatment by Kleiman et al. (2021) had a yield nearly 5 times higher than the mango trees that received a weed free treatment.

Research Results

Farm Production

Farm	Given quantity	Comparable quantity
Cunucu Fresh	20000 lettuce heads/month	240000 lettuce heads/year
Happyponics	2000 lettuce heads/week	104000 lettuce heads/ year
297 Farms	13000 lettuce heads/month	156000 lettuce heads/year
Farmaculture Fungi	-	
Eco Living	-	
Aruba Bee Haven	-	

Interview Results

As previously mentioned, the stakeholder were separated into three categories: 1) farm, 2) cununcu, and 3) hof'i. As two of the categories can only be found in the local context or in the neighboring islands, there were no rigid characteristics that the stakeholders had to adhere to fall into the categories. Instead, the characteristics for the categories are based on observations during site visits and information obtained during the interviews and how the stakeholders categorize themselves. The main characteristic factors that separated the categories are space use and technological application.

Figure 2 Honey Farming at Bee Haven

I. Characteristics of a farm:
- Efficient use of space
- Grow a limited variation of crops
- No animal husbandry
- Advanced technological application
- Revenue oriented

Farms on Aruba can be compared to farms elsewhere in the world; however, it still does not feel appropriate to use the general definition of farms and apply it to Aruban farms as some factors are vastly different. For this report the definition of farm has been tailored to Aruban farms specifically.

Aruban farms use space exceptionally efficient. They produce considerable quantities in relatively small spaces. While some farms do have access to substantial plots of land, the actual production is happening in small, closed spaces, greenhouses. One of the bigger greenhouses visited was roughly 15mX8m. To produce enough crops to have winnings in the relatively small spaces, farms use technological applications. Farm owners interviewed use technological interventions in the crop growing process. All grow their crops in controlled environments, this is in accordance with the actual food production process happening inside greenhouses. At the time of the interviews, all lettuce farms on the islands were using hydroponic systems to grow their produce. Although, some are thinking about switching to more efficient systems, the transition is yet to happen. The hydroponic systems are very well suited for lettuce farming, as they are equipped with multiple sensors that control the water temperature, water flow, pH, and nutrient contents that the plants require. Seeing that lettuce does not grow naturally on Aruba, these are all necessary

factors. The fungi farm that was interviewed does not use a hydroponic system since that is not necessary for fungi growth. However, they also produce in controlled environments where the temperature, humidity, ventilation and soil pH are monitored. From the interviews it was clear that the farms only grow a limited variation of crops. Curiously enough, none of the farms on the island grow local crops. For this reason, the farms are required to use technological applications to have an efficient production.

What alienates Aruban farms from the traditional definition of farms, is that they are all strictly horticulture farms. During the interviews the stakeholders said that they currently do not and would not consider expanding into animal farming. And what truly separates the farm category from the other two categories, is that farms are all revenue oriented. Farms are business ventures, with business plans and investors. All the interviewed farms mentioned that sustainability and food security on the island was a partial reason as to why they started their business venture, however the overarching reason is that all saw a gap in the market that they could fulfill and earn profits in. Placing honey producers in the correct category was a difficult process. They fit in the criteria for both farms and cunucu's. While local honey productions are not as efficient with their space use as farms and do not use many technological interventions, they still best fit under the farm umbrella. Honey producers are ultimately considered farms as at their core they are also business ventures that operate with the goal of making a profit.

II. Characteristics of a cunucu:
- Inefficient use of space
- Passed down through the generations
- Are passion projects for the owners
- Produce little to no profits
- Use traditional agricultural practices
- Are a mixture of growing crops and small animal husbandry

Aruban cunucu's should technically also fall under the farm umbrella term, however it does not seem correct to group them together, their differences are more important than their similarities.

Figure 3 Goats at a local cunucu

Aruban cunucu's make distressingly inefficient use of their space. Cunucu's, most if not all, are big plots of land where the owners plant their crops and keep livestock. In contrast to farms, cunucu's produce very little when taking account how much space they are using for the production.

The low production of cunucu's can be partly credited to them being passion projects. Many cunucu's on Aruba have been inherited from one generation to the next, leading to the same cunucu being in the family for hundreds of years. One cunucu owner even shared that it had been in their family for 500 years. Therefore, working in the cunucu is a way for the owners to feel connected to their heritage and cultural traditions. All the interviewed cunucu owners shared that the cunucu is not their main source of income and they all partake in the jobs in the 'cash economy'. This plays a part in the inefficient use of space, as they do not depend on the cunucu for their livelihoods they do not see the need to make costly investments on their land.

All Aruban cunucu's shared that they prefer working the land in more traditional ways. While they did not say they were outright against technological application in their cunucu, most of them prefer to work the land as their ancestors before them have. This sentiment was shared by all the owners of old family cunucu's. This is once again linked to wanting to maintain cultural traditions. As they prefer not to use technological interventions, all cunucu's grow crops that are already adapted to the island's harsh climate, which is a big difference from farms that control the climate for their production.

A major difference between farms and cunucu's is that cunucu's do participate in animal farming. All cunucu's interviewed shared that they keep either goats or chickens or both. Goats and chickens are known as 'bestia chikito' on the island

and are more 'traditional' livestock as well. When asked why they do not keep bigger animals such as pigs or cows, in spite of the fact that they had space for them, the cunucu owners all mentioned that bigger animals were too expensive to keep. The little production cunucus do make, is mostly for the owners own immediate family's consumption. Some mentioned that they sell what they cannot consume to friends and family. All of these criteria do not apply to all cunucus, as one of the owners did mention that the cunucu is treated like a side business.

III. Characteristics of a hof'i:
- Inefficient use of space
- Passion projects
- All crops compatible with local weather
- Very little profit
- Minimal us of technological applications
- Seasonal crops
- Small animals are possible

Unlike the previous two categories hof'is do not fall under the general umbrella definition for farms. Nevertheless, hof'is share many similarities with cunucus. Like cunucus, hof'is also make inefficient use of their space. However, unlike the previous category, hof'is are not big plots of land. A more accurate description for hof'is would be really big home gardens. The inefficient use of space is due to the buildings, houses and other construction on the property, hindering which type of crops can be planted, a hindrance that the other two categories do not have. Hof'is are also passion projects, like the previous category the owners do not depend on the production of their home garden for their livelihoods. The production of hof'is is mostly for the own consumption. What they cannot consume they share with family and friends, or make small treats that can be sold. Hof'is are not very profitable, they produce less food than both cunucus and farms, be that as it may they still produce enough to satisfy the own consumption. Like cunucus, hof'is also keep seasonal crops that are adapted to Aruba's weather, therefore they too do not need technological intervention to grow crops. The only intervention reported were simple dripping systems, one with a pump and one that works with gravity. Unlike farms, hof'is can keep small animals such as chickens. Only one hof'i owner was interviewed for this paper, as the opportunity to interview other hof'i owners did not present itself. The mention of another hof'i was from a cunucu owner that has both a cunucu and a hof'i in their home

The first and most expected finding is that water is a big constraint to stakeholders in all categories. This was the most anticipated finding as Aruba has an average rainfall on only 450 mm/year (Boyer, et al., 2020). And there are currently no other sources of fresh water on the island, thus all potable water is produced from sea water by reverse osmosis process installed at W.E.B Aruba (WEB N.V, n.d.). The SWRO process uses high amounts of energy, energy that comes from fossil fuel combustion, for this reason the water on Aruba is relatively expensive. Although

W.E.B Aruba offers special flat rate fees water prices per m^3 for cunucu's (WEB N.V., n.d.), stakeholders have shared that there are many barriers in the way to access this support.

The second finding is only applicable to cunucu's. As previously mentioned cunucus on Aruba are passed down through the generation, this has been happening for hundreds of years already. This is the only common theme that all the interviewed cunucus fall under. All of the cunucu owners complained about the younger generation, their children. They complained about rarely getting any help in the cunucu from their children, as they prefer to stay inside and rather get jobs in the 'cash economy' that are not as labor intensive. They all also expressed worry for the future of their family cunucu. They worry about keeping traditions and have voiced their concern that local practices and knowledge will be lost. Some even said that if their children do not eventually step up to take responsibility of the cunucu when they themselves become too old to take care of it, they will be forced to sell it to someone outside of the family for the cunucu itself not to be lost. From this it is clear again that cunucu are not just a way to produce food, they have strong cultural ties to Aruban tradition.

The third finding is that all the endeavors under the farm category started as hobbies or passion projects and then grew into businesses, big or small. The farm owners shared that they experimented with gardening and growing food for themselves first, due to curiosity or hobby. They only started their businesses once they realized there was a gap in the market for the product that they offer, more importantly they realized there was demand for their products. Many started because someone who works in a restaurant or kitchen made comments to them about lack of local produce and how much food waste they have. Only one person has said that they started the endeavor with the goal of turning it into a profitable business, unlike other farmers this farm owner started their business with food security and sustainability on their mind.

The fourth finding is that almost all producers in all three categories have shared how the market is big enough for everyone to produce, and even then that would still not saturate the market.

The fifth finding, only applicable farms, is that they do not advertise their products as locally grown. None of the farms spend much if any money on traditional advertising. They all shared they use social media as advertising, but even then, they do not explicitly state that their products are locally grown.

The sixth finding is that electricity is another big cost, for farms especially. As they use a lot of equipment to keep production optimal, they consume a lot of electricity.

The seventh finding is that women do not play a big role in Aruban food production as was expected. Across the world women are the dominating workforce in the food production industry, at least the food that is not used as fuel or feed for animals

(Hickey & Unwin, 2020). Of all the stakeholders interviewed only three were women, and those were the only producers that concurred that women were in volved in their production process.

The eighth finding is that cunucu owners have a lot of problems with loose dogs. Even though the 'Ley di cacho' entered into force on January 1st 2015 (Gobierno Aruba, 2015), in which it is stated that dog owners must keep their dogs in their own yards at all times and if that is not possible that the dogs must have a 10-meter-long leash to stay inside the owner's yard. The cunucu owners reported that loose dogs are a threat to their livestock.

The ninth finding is that in all of the interviews some sort of displeasure with the government was expressed. All were due to different specific reasons, even so they can all be grouped under that they wished the government would support them more.

The tenth finding is more sensitive in nature. This was not explicitly stated in any of the interviews, but there was a pervasive us and them mentality.

The final finding and one of the most relevant ones for this paper is that the COVID-19 pandemic did not affect food production in the way that was expected. Or rather it affected food production in an expected unexpected way. It is a widespread fact that Aruba is extremely dependent on imported food (Boyer, et al., 2020). Therefore, when the COVID-19 pandemic first started and the island went into a strict lockdown, it is logical to assume that people might have started to worry where their food would be coming from. In fact, there is no need to assume that there was in fact panic, a few days before the lockdown was made official on the 17 of March 2020, the supermarkets all had long lines of people with shopping carts full of food. It was to be expected that people would try and produce food for themselves somehow. Which they did, both Santa Rosa and Canashito shared that they had more people than regular come. Santa Rosa reported that more people than is normal for them came asking for advice on gardening and how to keep livestock during the pandemic year, 2020. They also shared that some people were producing so much they wanted to sell it to Santa Rosa, however they were less than pleased when informed that the government department is not there to buy produce. Canashito reported that during the pandemic year they sold roughly 20000 to 25000 chicks, both to their regular customers and to private individuals. What was not expected is for people to stop so suddenly when things went 'back to business as usual'. Both instances reported that they drastically saw the number of visitors go down by 2021. Canashito shared that in 2021 they only sold roughly 15000 chicks. Which is drastically less when compared to the pandemic year. They also shared that they only saw such a big difference in chicken sales, the other small animals they sell sold routinely during the pandemic year.

Stichting Rancho is an organization committed to improving the oldest neighborhood in Oranjestad; Rancho. They organize events to highlight and preserve the cultural significance of Rancho. Stichting Rancho has been getting funding from CEDE Aruba since 2015, they also rely on donations from the private sector and the community They established a community garden in 2020, Hof'i Bario Rancho. Hof'i bario was created to meet the demand of the neighborhood to learn how to cultivate their own food and to help alleviate the food insecurity afflicting the community at the time. They planted different crops that are adapted to the local weather, such as spinach, green beans and small cucumbers. They also accept crops back from the community, which will be sold during their monthly 'Marshe'. The 'Marshe' is also a place where individuals can come together to share their knowledge. During the lockdown Stichting Rancho were handing out seeds and food packets to their community. Although the hof'i had been an idea for some time already, they only started it in the pandemic due to necessity and the community finally being able and having the time to invest in gardening. While the hof'i was doing fine when people had to stay home, it quickly lost traction as the lockdown was lifted and people had to go back to work. Since then the hof'i has mainly been maintained by SPO students. Furthermore, the materials were also an obstacle. They had not expected gardening material to be so costly and have to be constantly replenished. Stichting Rancho is an interesting case study in food security. Community gardens are a great idea in theory, however when applied they require a lot of input, time, manpower, money, etc., from the community. Established community gardens have a more difficult time acquiring funding and reoccurring support than new gardens (Diaz, Webb, Warner, & Monaghan, 2018). For community garden to be successful, there has to be continual community engagement and support.

Data analysis

Some stakeholders shared that they had tried to apply for the special water rate, as this would lower their water costs substantially, but due to multiple reasons and a long bureaucratic process they stopped halfway. Surprisingly, the water costs were not the only thing the stakeholders mentioned. Many of them shared how they believed that the quality of the water from WEB was not adequate for watering plants. The farms, excluding the honey producers, all alter the water's pH and nutrient content due to the type of crops they grow. The cunucu owners do not do this, as the water is not inherently bad for their crops. However, they did say that the water from WEB is too basic and does not have enough 'good' nutrients for their crops. This is accurate as WEB has reported that the water that comes out of the pipes is alkaline and has a pH between 8.5 and 9.5 (WEB N.V., n.d.). The optimal pH for plants is slightly acidic, between 5 and 7 (Cox, 1995). One of the cunucu owners

went as far to share that they add lemons or other acid fruits to their drinking water for it to become more neutral as they do not trust the water W.E.B produces.

When asked how they felt about the competition and if they felt they could compete in the current market, the lettuce farms answered that although they all produce the same product and roughly the same amount, all three farms barely cover 5% of the lettuce demand on the island. The fungi farm said that although they produce different species of fungi than their competitor, the market was big enough. Even the honey producers said that the market was big enough. This last group produces the same raw products and even some of the same products from the honey and beeswax. The market on the island is big enough for all the current food producers and future food producers to thrive due to tourism and the high population count.

It is worth noting that all of the farms place a small Aruban flag somewhere on their packaging. Therefore, while they might not explicitly advertise their products as locally grown, they do actually do it implicitly, by adding an Aruba flag to their packaging. This signals to consumers that said products were produced or made on the island. The stakeholders also all shared that they rely on word of mouth for people to find out about them and get new customers, this is common on small islands

One of the farms shared that their current electric bill was roughly 3000 florins per month and they were not yet at full capacity. All the farms, excluding the honey producers, shared that they plan on using more sustainable energy in the future. The more established farms shared that they are in the process of going solar, as the investment is more affordable in the long run as opposed to paying expensive electric bills. They also shared that they felt hindered by the policy on renewable energy production. And not only is the policy an obstacle but they have to follow a tedious vetting process with Elmar, as individuals/businesses are not allowed to install more than they consume. To them it feels more like an obstacle than help.

The observation that women are underrepresented in the local food production, although a personal bias, is a legitimate finding that Aruba does deviate from the norm of women being the biggest group to participate in food production. This is partly due to women's work in the sector being unaccredited

According to the cunucu owners, dogs come in at night and prey on their younger or weaker goats. The dogs also pee and poop in their cunucu making it so their goats will not graze on those spots until the smell goes away. One of the cunucu owners even shared how they followed the dog a long distance before it went home, they expressed resentment of not being able to do anything as it would be an obstruction of the law.

Some stakeholders expressed annoyance at the laws and policies the government has in place, i.e., the policy on renewable energy. They felt these laws and policies were a restraint, and expressed confusion because according to the stakeholders they were

not doing anything wrong. Other stakeholders expressed their displeasure with the government by sharing that even when they want to do something positive, food security wise, the government is slow to process permits. One food producer complained that due to the government entities having a lack of knowledge of the product they were trying to bring to the market, they were extending the regular time that it would take to receive a permit. The cunucu owners who keep animals expressed displeasure with the government's lack of control on animal feed prices, that in 2022 alone have risen three times already. All of them expressed disappointment with the government for not incentivizing more people to start home garden or food production businesses. Some of the stakeholders criticized the government for not incentivizing the public to start producing food yet when individuals took the initiative themselves the government wanted to show up and bring the press with them to receive the positive publicity.

Not all of the food producers interviewed were locals or had long family histories with farming, some were from immigrant families. The non-local food producers shared that they felt they have faced hardships due to their immigrant background. They felt that it was harder for them to break into the market, compared to their local peers and that they received less help in general from the community of food producers on the island. They also shared that they have received harsh criticisms, and they feel like they have to consistently produce at higher standards with no room for error. Another reoccurring theme during the interviews was the contempt towards the Chinese community on the island. As a local it is widespread knowledge that the Chinese community on the island are also food producers, whether it be for their own consumption or to sell to supermarkets. In multiple interviews the Chinese community as food producers was mentioned in a negative undertone. Although the Chinese community does play a role in Aruba local food production, the opportunity to interview any of them did not arise. It would be interesting to know how they feel and what hardships they have had to face.

WFP Survey Results

The World Food Project Survey had a total 1219 responses in all five rounds across all three islands. Aruba had 556 responses. However, as not all the questions were required in the survey there may be discrepancies in the total number of answers per question. This is something the research has to pay extra attention to, as it can skew the actual results. The first round of the survey did not have all the questions therefore the total of answers per question is not the same as the number of responses. To get a more unskewed version of results we will only be talking about the results in percentages rather than number of answers.

This is the information gathered from the responses.

- The gender distribution between the respondents was almost equal, with 56% being female and 44% being male.

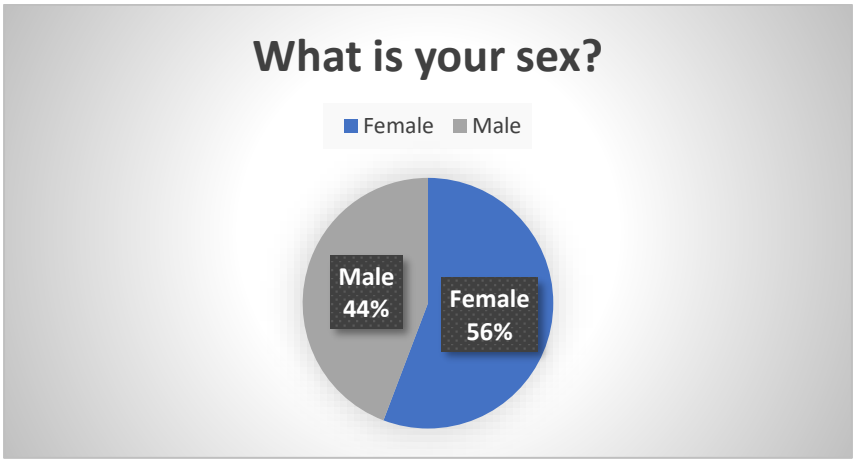

Figure 4 Sex distribution

- The respondents were mainly middle-aged adults. 8% in the 25 and under bracket, 33% in the 26 to 40 bracket, 47% in the 41 to 60 bracket, and 12% in the over 60 bracket.

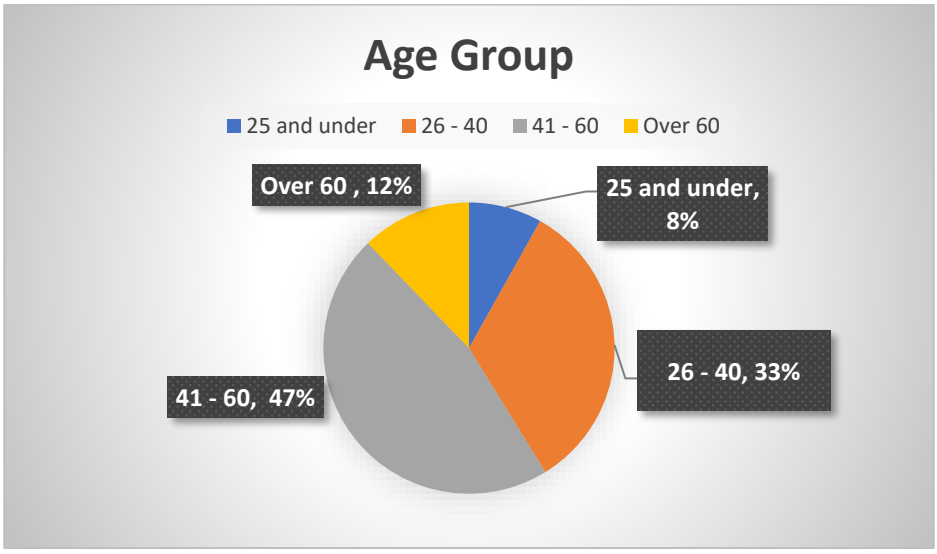

Figure 5 Age distribution

- The majority of households were single households 8% and house holds of two or three or four of five people, 29%, 21%, 22% and 12% respectively.

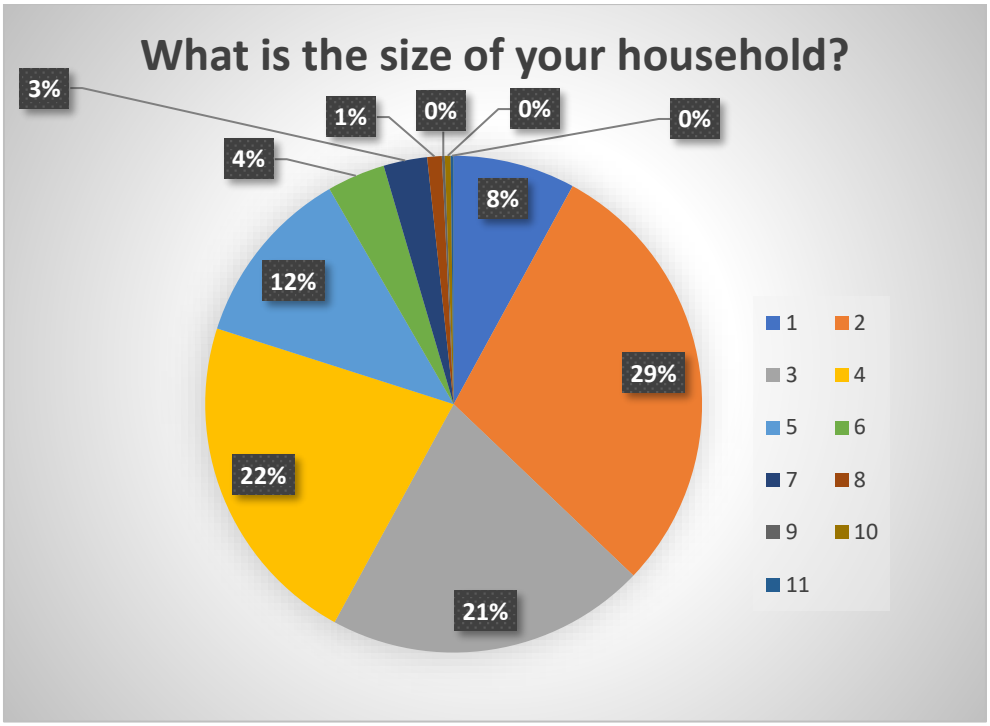

Figure 6 Household distribution

- The availability of fresh food items in markets/stores was questioned. 77% of respondents answered that they were always available, 21% answered that the items were partially/sometimes available, and 2%did not know.

Figure 7 Availability of fresh food items

- The availability of basic food items was also researched, 91% answered that the items were always available and 9% answered that they were only partially/sometimes available.

Figure 8 Availability of basic food items

- 77% of respondents reported an increase in food prices, 21% reported no change and 2% reported a decrease in food prices.

Figure 9 Perceived changes in food prices

- 84% of respondents reported to having changed their shopping behavior compared to before the pandemic, while the other 16% respondent no change at all.

Figure 10 Changes in shopping behavior

- Of the respondents whose shopping behaviors had changed, 134 reported that they were buying larger quantities than usual, 46 reported to having adopted online shopping, 34 reported going to different stores, 45 reported buying cheaper or less preferred foods, and 4 reported buying smaller quantities.

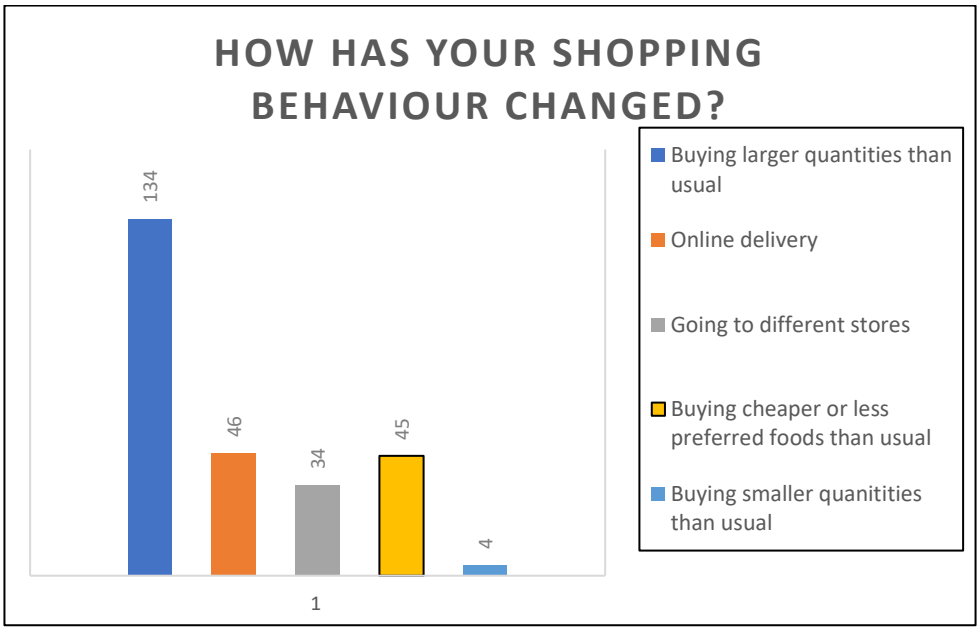

Figure 11 Changes in shopping behavior

- 72% of respondents reported to having lost their jobs or having a reduced salaries/revenue since the COVID-19 outbreak, 18% reported no change in income, 7% reported to having to resort to secondary/alternative sources of income to maintain the income level and 3% reported an increase in employment and salaries.

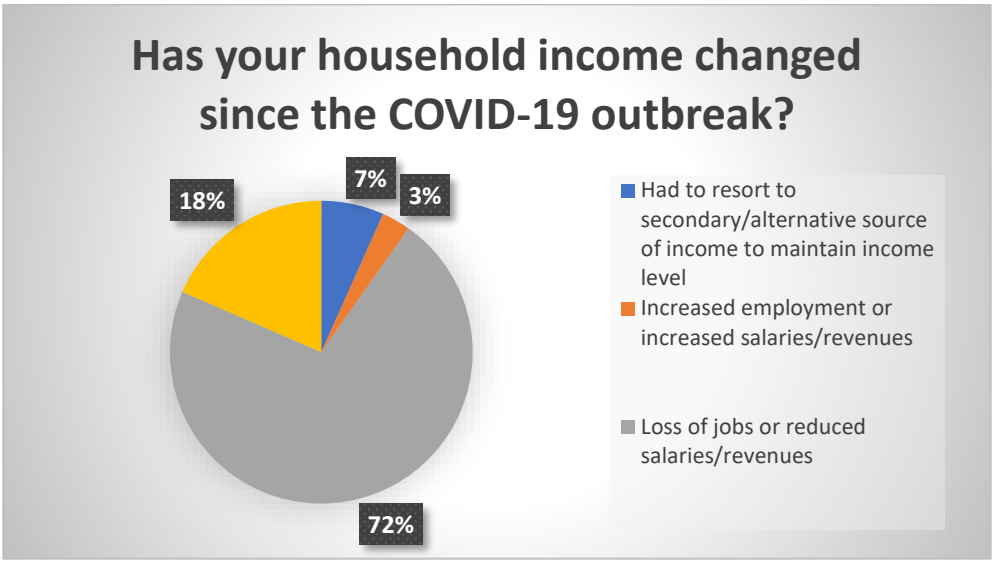

Figure 12 Income changes

- At the time of the survey 82% of households were not involved in livestock farming, 14% were involved in livestock farming for their own consumption, 3% were involved in sale and their own consumption and 1% was involved only for sale.

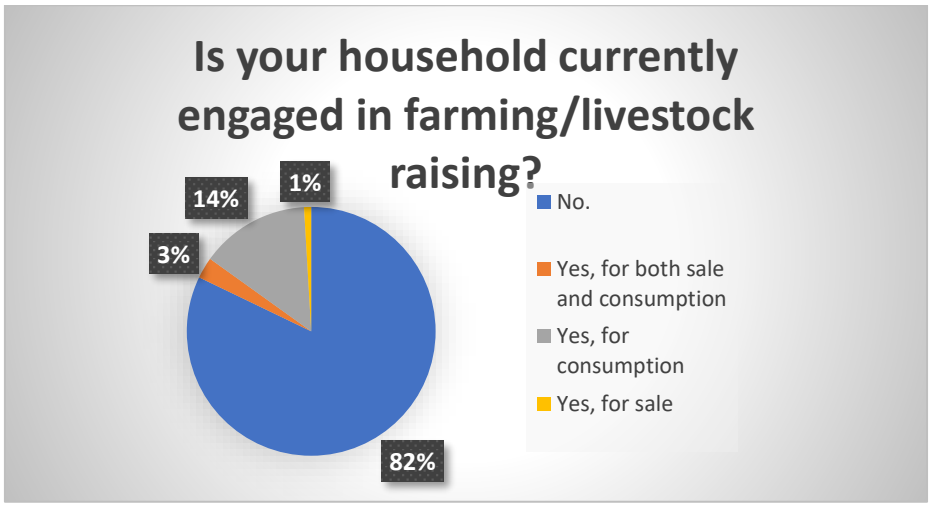

Figure 13 Households engaged in farming

The other questions are available in the appendix

Discussion & Conclusion

Answer research questions

Taking into consideration all the previously mentioned factors that influence food production, high water and energy costs, limited space, harsh weather, infertile soil, etc. Aruba still produces a substantial amount of food, a solid 500,000 lettuce heads each year. The other stakeholders could not give exact numbers on their production, due to not being at that stage of their production yet or due to their production not being constant enough to give reliable data. The production of the lettuce farms is aided by the use of technology, otherwise they would not be able to sustainably produce. From the interviewed stakeholders, only lettuce, mushrooms, honey and honey products, goats and chicken are being produced. Although this is a step in the right direction to achieving food security, it is not a real diet. A staple in most diets in Aruba is the kipashi bread, it is even an item on the national basic basket as per AB 1991 no.GT 17. Kipashi cannot be made from the food produced on the island.

From the literature study, technological interventions are beneficial and needed to plant crops on the island. Greenhouses are necessary to increase product yield, and for non-native crops that are adaptable. Greenhouses require less space per crop, reduce water wastage and have shorter crop cycles than regular farming. Combining aquaponic and hydroponic systems with greenhouses is how the lettuce farms on the island ensure their constant output.

It is unlikely that these systems will be adopted by the general population. While affordable for businesses and people planning to turn a profit from them, they are expensive and time consuming for people who want to grow food for just their households.

For the general population that might still want to grow their own food, irrigation systems might be the more realistic option. They are relatively affordable; help reduce water wastage and can be automatized therefore requiring less hours of labor. For the cunucu owners, specialized irrigation systems are a plausible option. While this demographic is not entirely open to technological interventions, as they want to continue working the land as their ancestors have before them, it is necessary to realize they no longer live like their ancestors. All of the cunucu owners interviewed have full time jobs to support them, they do not have the same amount of time their grandparents might have had to invest in farming. The integration of irrigation systems could help alleviate the time-consuming nature of maintaining a cunucu while not necessarily disrupting the cultural practices. Buried diffusers might be the best option in this case, as they are not unaffordable, can be automated and help save water by placing it where it will not evaporate as fast.

As businesses started opening and the tourism economy slowly picked up again, the Aruban population lost interest in growing their own food. This was noted by Canashito, Santa Rosa and Stichting Rancho. The loss of interest could be due to a

genuine lack of interest in gardening, or, as the previous stakeholders speculated, due to having less time to spend on leisure activities and no longer feeling like food shortages were imminent. It is very unlikely that the Aruban population will decrease food insecurity by cultivating their own food.

While Aruba has a strong food network, it could be considered food insecure when analyzing it through the lens of all four dimensions. Physically and economically food is always attainable in stores, that's access and availability. However, it still remains food insecure as economic access to food is sensitive to all political instabilities in Latin America and the US. The island has a high GDP per capita, Afl. 6,079M in 2019, meaning that there is a great amount of money circulating, but it is not equally distributed. Some members of the population will continue to afford food prices, even through the shocks in food prices the increasing instability in Latin America causes, but the rest of the population will not. It is likely that they will have to either adapt their eating habits, change their current diets or work longer hours. The COVID-19 pandemic definitely made the population aware of this, if Santa Rosa and Canashito' increased activity during the lockdown is anything to go by. Food security on the island could be better studied if CBS would put out consistent reports on how the populations money is spent and how inflation affects people at different level of income along with accurate production figures. As Boyer et al. noted in their 2020 report, Aruba's food security comes from the population's robust purchasing power.

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Appendices

Appendix A: Sustainable Development Goals

Figure 14 Sustainable Development Goals, retrieved from UN

Appendix B: General interview questions

1. When was the company started?
2. What is produced?
3. What technology do you use?
4. Do you use water from WEB or another water source?
5. Is electricity used in the growing process?
   i) If yes, is the electricity from a renewable source or from ELMAR?
6. How much is produced each month?
7. Who are your biggest customers?
8. Do you advertise your products as locally grown?
9. Are you planning on expanding your production?
10. What motivated you to start with this business?

Appendix C: Stichting Rancho interview questions

1. You are a community garden; do you receive funding from governmental organs? Or is it all private funding?

2. Did your community fully accept you at first?
3. Does your community themselves think that they are benefiting?
4. Do you think that community garden/foundations are viable for other neighborhoods?
5. Did you help your community during the beginning of the pandemic? Do they think the foundation helped?
6. Are you planning something new for your hof'i? Any new technology? Or is it only on donations?
7. Do you teach your community how to garden themselves?

Appendix D: WFP results for Aruba

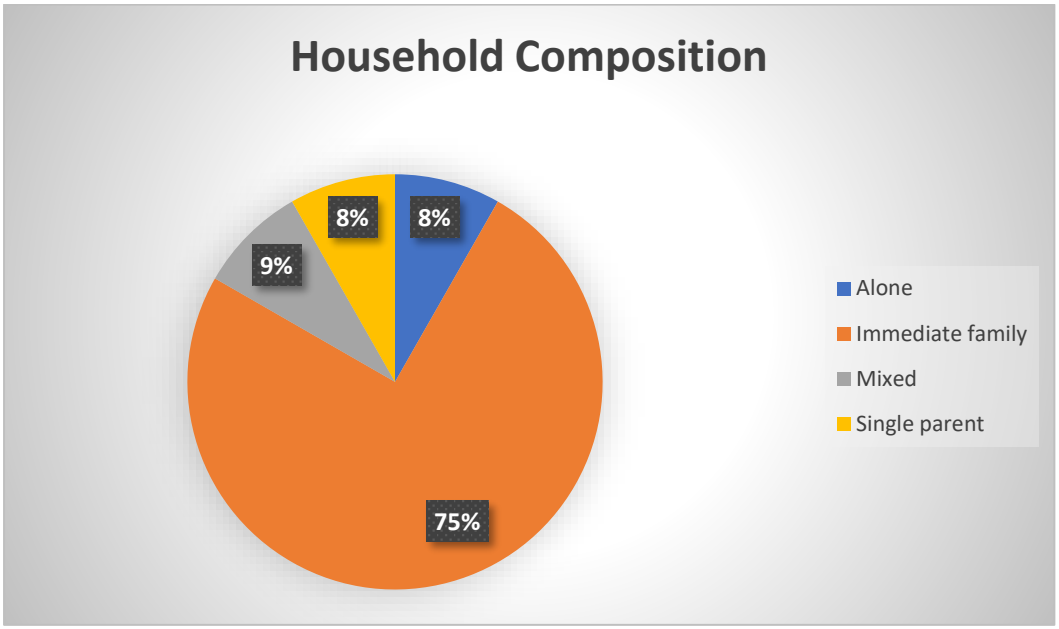

Figure 15 Household composition

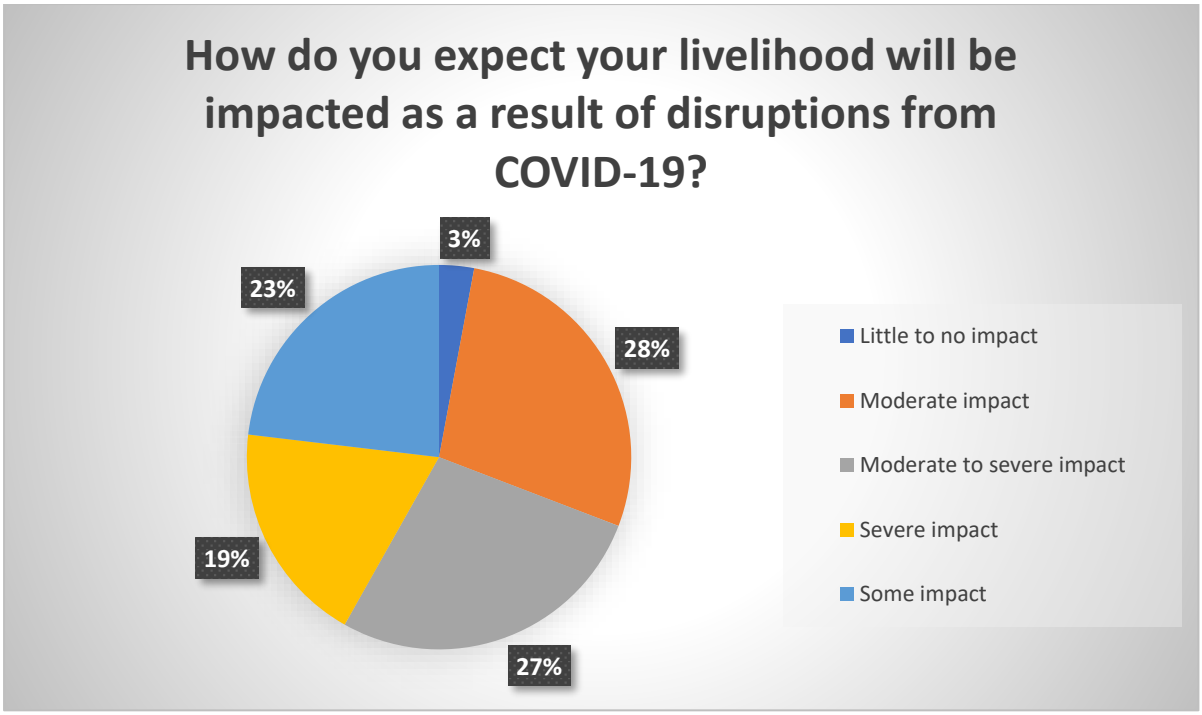

Figure 16 Impact of COVID-19

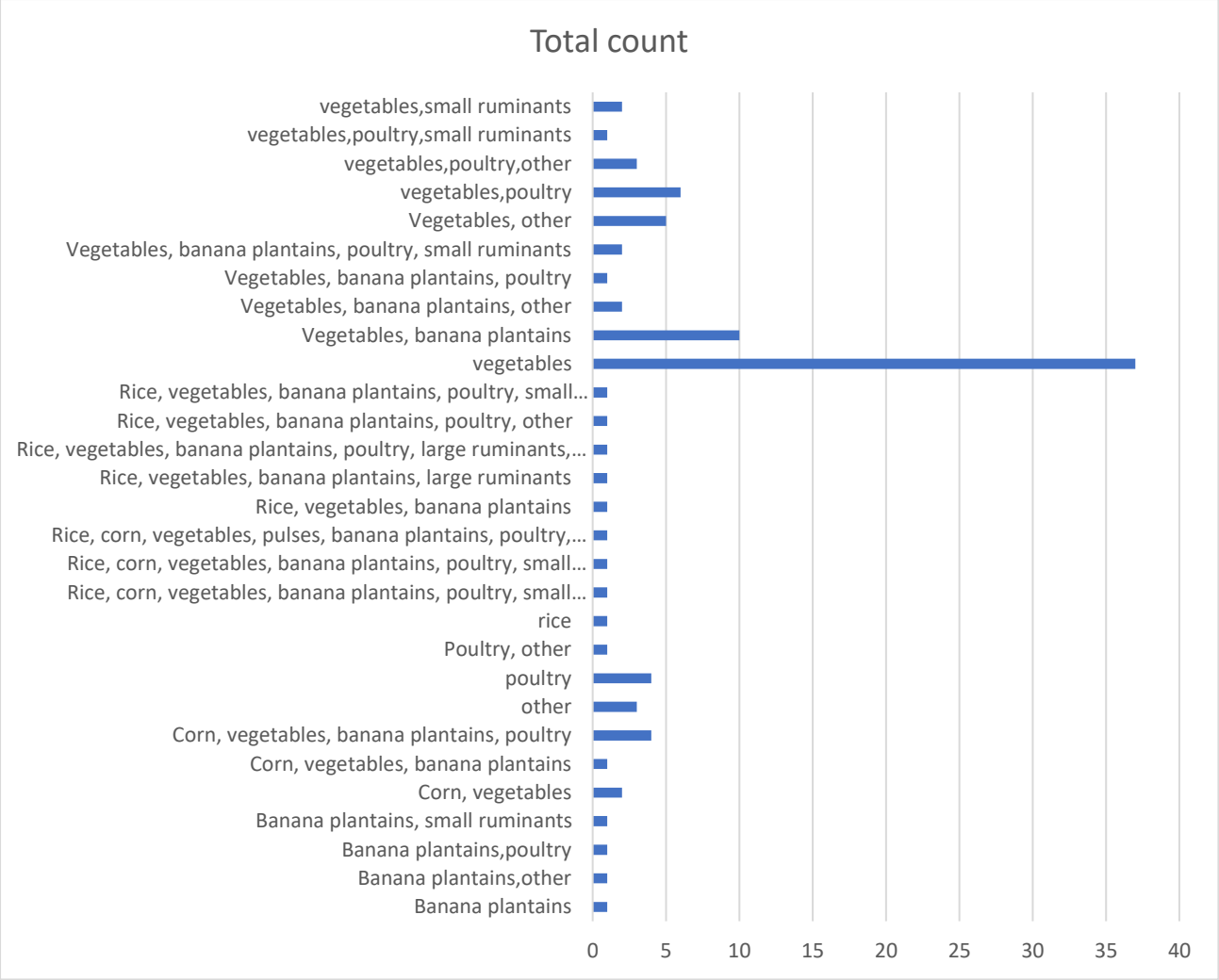

Figure 17 Farming items

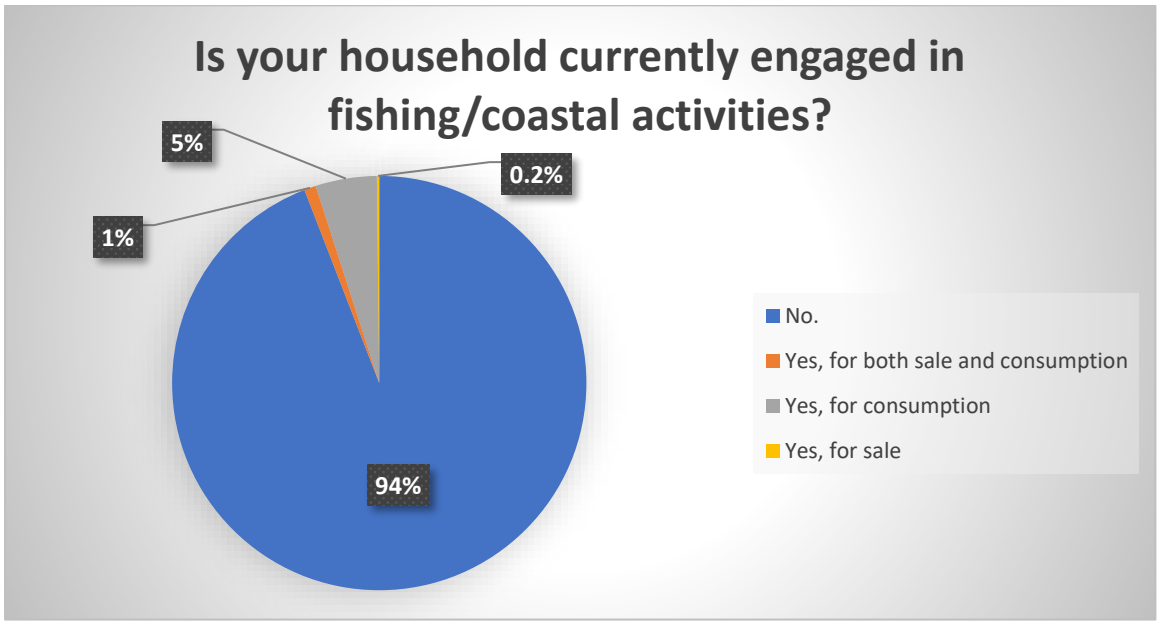

Figure 18 Households engaged in coastal activities

Appendix E: Reference graphs

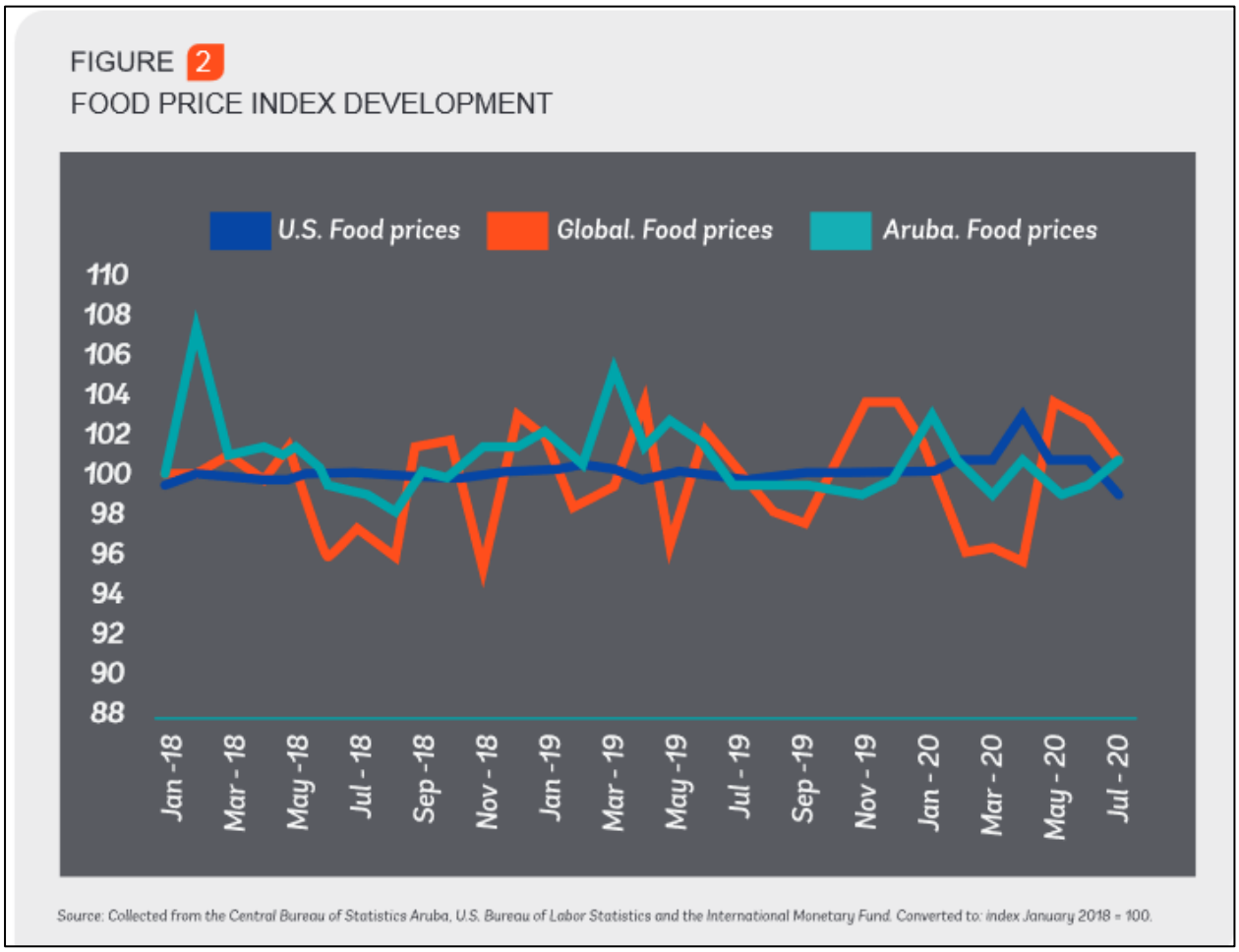

Figure 19 Food price development, retrieved from Boyer et al. 2020

Figure 20 GDP growth, retrieved from Centrale Bank van Aruba 2024

Appendix F: Penman-Monteith Equation

$$ET_0 = reference\ evapotranspiration\ \left(\frac{mm}{day}\right)$$

$$\Delta = slope\ of\ vapor\ pressure\ curve\ \left(\frac{kPa}{°C}\right)$$

$$R_n = mean\ daily\ net\ radiation\ \left(\frac{MJ/m^2}{day}\right)$$

$$G = soil\ heat\ density\ \left(\frac{MJ/m^2}{day}\right)$$

$$\gamma = psychometric\ constant\ \left(0.0671\ \frac{kPa}{°C}\right)$$

$$e_s - e_a = saturation\ vapor\ deficit(kPa)$$

$$T = mean\ daily\ air\ temperature\ (°C)$$

$$U_2 = wind\ speed\ at\ 2\ meter\ height\ \left(\frac{m}{s}\right)$$