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FISH SILAGE PRODUCTION AND USE IN THE CARIBBEAN
FEASIBILITY STUDY FOR BARBADOS AND SAINT KITTS AND NEVIS

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Top - Bridgetown Public Fish Market in Barbados (aerial view) © BGI
Below - Basseterre Fisheries Complex in Saint Kitts and Nevis © BGI

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FISH SILAGE PRODUCTION AND USE IN THE CARIBBEAN FEASIBILITY STUDY FOR BARBADOS AND SAINT KITTS AND NEVIS

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PREPARATION OF THIS DOCUMENT

This document is a compilation of the reports of the study commissioned in Barbados and Saint Kitts and Nevis to assess the feasibility of the production and utilization of fish silage. This initiative was undertaken with the cooperation of Argentina, the governments of the two countries and the Food and Agriculture Organization of the United Nations (FAO). It was jointly supported by "Towards a Caribbean Blue Revolution" (TCP/SLC/3601), the Climate Change Adaptation in the Eastern Caribbean Fisheries Sector (CC4FISH) project and MDF Funds (FAO Framework Project for Linking Responses to Rural Poverty and Climate Change with a focus on coastal communities, coastal areas and Small Island Developing States).

The study was led by the BlueGreen Initiative Inc. (BGI) and was conducted following its successful launch in Bridgetown, Barbados on 1 February 2019. The launch event was attended by representatives of the Barbados ministries of Maritime Affairs and the Blue Economy, Agriculture and Food Security as well as Youth and Community Empowerment, and officials from the Argentinean Embassy. The entire study was undertaken from March to July 2019. The Barbados interviews ran from 18 March to 29 March 2019 while the Saint Kitts interviews were conducted between 17 June and 20 June 2019. This was followed by national stakeholder workshops to discuss the findings, hold demonstrations on silage production and provide guidance for a way forward.

The individual country reports were prepared in August 2019. The compiled draft was thoroughly reviewed by FAO technical officers before the final version was edited and published.

ASTRACT

It is estimated that per year in Barbados, 585 tonnes of fish waste are generated at the two main public fish markets, and 936 tonnes of waste are generated at private fish processors across the island. Therefore, Barbados produces an aggregate of 1 521 tonnes of fish waste annually. At present, approximately 90 percent of fish waste and by-products are discarded at the landfill.

To produce fish silage on a large scale in Barbados the baseline cost (based on a 90 percent yield rate) is estimated to be USD 265 920, excluding the cost of fish waste and acids. Sales revenues based on competitor prices range from USD 528 485 to USD 2 044 900. During the fish silage demonstration workshop held from 23 to 26 July 2019 in Bridgetown, the cost of small-scale production (100 kg) was estimated to be USD 900 and USD 254 when using the chemical and biological methods, respectively.

The existing regulatory framework has the potential to facilitate the production and utilization of fish silage. However, Clearance and permission may have to be institutionalized in order for fish silage to be produced and utilized in, and or as, animal feed. These conclusive findings subsequently prompted FAO to engage in a partnership with the Caribbean Agriculture Research and Development Institute (CARDI), to develop the silage-based feeds and document their effects on the growth performance of select animals.

In Saint Kitts and Nevis, by using two methods of calculation, it is estimated that 55 tonnes of waste and approximately 13 tonnes of fish waste are generated annually. Both of these estimates are undervalued.

The production of 100 kg of silage per month was estimated to be between USD 424.10 and USD1 145.08. All these costs were perceived to be restrictive to the production of silage. At USD 0.75 per 0.45 kg, revenue from silage production is estimated to be USD 46 296 annually, producing 11 574 kg of silage. However, this price is uncompetitive when compared with current complete feed prices. Feed is subsidized and sold at USD 13.125 per 22.68 kg or USD 0.24 for 1 kg.

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ABBREVIATIONS AND ACRONYMS

ADS	Agriculture Development Strategy
BARNUFO	Barbados National Union of Fisherfolk Organizations
BFC	Bridgetown Fisheries Complex
BFC	Basseterre Fisheries Complex
BFD	Barbados Fisheries Division
CAPEX	Capital expenditure
CARDI	Caribbean Agriculture Research and Development Institute
CARICOM	Caribbean Community
CCCFP	Caribbean Community Common Fisheries Policy
CCRF	Code of Conduct for Responsible Fisheries
DMR	Department of Marine Resources
FAC	Fisheries Advisory Committee
FAMR	Fisheries, Aquaculture and Marine Resources Act
FMP	Fishery management plan
GDP	Gross domestic product
IICA	Inter-American Institute for Cooperation on Agriculture
MDF	FAO Framework Project for Linking Responses to Rural Poverty and Climate Change with a focus on coastal communities, coastal areas and Small Island Developing States
MENB	Ministry of the Environment and National Beautification (formerly known as the Ministry of Environment and Drainage, MED)
MMA	Marine Managed Area
MMABE	Ministry of Maritime Affairs and the Blue Economy
NAS	National Adaptation Strategy
NFC	Nevis Fisheries Complex
NGO	Non-governmental organization
NIA	Nevis Island Assembly
OFC	Old Road Fisheries Complex
OPEX	Operational expenditure
SBRC	Sustainable Barbados Recycling Centre
SNAPPER	The Saint Kitts and Nevis Aquaculture Pilot Project and Environmental Research
SSA	Sanitation Service Authority
SWMC	The Solid Waste Management Company

EXECUTIVE SUMMARY

Food loss and waste occur in all parts of the fisheries and aquaculture value chain which includes: capture fisheries, aquaculture, processing and storage, wholesale, retail, transport and consumption (FAO, 2019). To minimize the loss and waste produced in the fish and aquaculture value chain, and by extension improve fish waste management strategies, much research has been done to develop methods to convert these wastes into useful products such as fish emulsion fertilizer and fish silage.

This study seeks to assess the feasibility of the production and utilization of fish silage in Barbados and Saint Kitts and Nevis. A mixed methods approach was used where both primary and secondary data were integrated into the study.

Barbados

In Barbados the methodology of the study consisted of a literature review, an analysis of secondary landing site data and semi-structured interviews with 13 key stakeholders.

It is estimated that per year, 585 tonnes of fish waste are generated at the two main public fish markets, and 936 tonnes of waste are generated at private fish processors across the island. Therefore, Barbados produces an aggregate of 1 521 tonnes of fish waste annually. At present, approximately 90 percent of fish waste and by-products are discarded at the Mangrove Landfill. Ad hoc activities account for the remaining 10 percent: (i) the creation of fish emulsion that is used as fertilizer for crops; (ii) fish waste is used as animal feed; and (iii) fishmeal is created for value-added products such as fish burgers, fingers, wieners and sausages.

Given the majority of fish waste and by-products are discarded at the landfill, and the number of key players in the industry, multiple supply chain scenarios are developed for the production of fish silage. Based on feedback, fish silage production by a private entity is preferred, rather than production being operated by government. It is recommended that government could incentivize the production through providing land and buildings at a discounted rate. Any future supply chain configuration of the production of silage is predicted on optimal waste sorting techniques which rationalize waste streams (skins, offal, fish oils, etc.) to provide the highest quality input into any further value-added product.

Stakeholders noted that producing compost maybe a more feasible alternative to fish silage and that composting may be more financially viable, with minimal infrastructural investment needed. To produce fish silage on a large scale in Barbados the baseline cost (based on a 90 percent yield rate) is estimated to be USD 265 920, excluding the cost of fish waste and acids. Sales revenues based on competitor prices range from USD 528 485 to USD 2 044 900. During the fish silage demonstration workshop held from 23 to 26 July 2019 in Bridgetown, the cost of small-scale production (100 kg) was estimated to be USD 900 and USD 254 when using the chemical and biological methods, respectively. A number of annual operating surplus estimates are also determined based on the use of various types of acids and possible selling prices. Essentially, locally produced fish silage must utilize the high protein content of the product as its primary market advantage.

The existing regulatory framework has the potential to facilitate the production and utilization of fish silage. However, existing policy instruments do not directly define the roles and responsibilities of key actors, nor do they address aspects of market and institutional arrangements regarding the handling of rest raw materials, fish offal and the production of fish silage, despite provisions made in the Fisheries Act and the Code of Conduct for Responsible Fisheries (CCRF). The absence of such regulations can pose constraints and challenges for the successful implementation of fish silage production. Clearance and permission may have to be institutionalized in order for fish silage to be produced and utilized in, and or as, animal feed.

These conclusive findings subsequently prompted FAO to engage in a partnership with the Caribbean Agriculture Research and Development Institute (CARDI). The initiative is ongoing and expected to be completed by the end of 2020. It aims to develop the silage-based feeds and document their effects on the growth performance of select animals.

Saint Kitts and Nevis

In Saint Kitts and Nevis, key informant interviews were conducted with fishers, boat owners, fisheries management officials, staff at the fisheries complexes, pig farmers and an aquaculture farmer/researcher. In all, 12 interviews were conducted using a semi-structured questionnaire instrument tailored to each stakeholder group.

Whereas in Barbados the main sources of fish production and waste are from imported fisheries and local catches, in Saint Kitts and Nevis the local catches are the main source, with on-board gutting being the primary method of discarding fish waste. Two methods were used to calculate the amount of waste generated: (i) a constant ratio of 20 percent was utilized and it is estimated that 54 880 kg (121 000 lbs) or 55 tonnes of waste is generated annually; and (ii) using a range of waste ratios depending on species type resulted in an estimate of 12 860 kg or approximately 13 tonnes of fish waste annually. Both of these estimates are undervalued and given the disparity between the two estimates, the lack of accurate data is a major limitation of the study. Future data collection should record fish weight inclusive of viscera and new calculations need to be made to improve the accuracy of the waste estimates.

Agriculture production data at the national level is scarce. Livestock feed is supplied primarily by the Department of Agriculture at a subsidized rate of USD 35 to USD 40 per 22.68 kg (50 lb) bag and the department supplies approximately 900 bags/20 441 kg (45 000 lbs) of feed per month to the market. In general, productivity of the livestock sector in Nevis was considered to be significantly greater than the livestock sector in Saint Kitts. Farmers noted that the feasibility of fish silage usage is based on three criteria including: (i) fish silage must enter the market at a significantly lower per unit price than existing feeds; (ii) fish silage must be convenient for farmers to use; and (iii) fish silage must be properly managed and processed to ensure stable nutritional value standards.

The longstanding cultural practices of local farmers will be a significant consideration for the development of a productive silage industry. Any changes to the longstanding habits of feed use will require strong education campaigns to convince users of the benefits of fish silage. Another prevailing practice that would have to be addressed is that of gutting fish at sea and discarding the subsequent waste. This habit means that at present fish waste that includes viscera cannot be easily collected from the fisheries complex unless efforts to change this cultural practice are given priority. Key informants stated that almost all of the fish waste generated is discarded at sea, but if there was an alternative use to be exploited they are willing to change their practices. Fishers in Nevis identified they would be more than willing to store the fish offal on board their vessels and deliver it to shore if it could be sold for ECD 2.00/USD 0.75 per 0.45 kg (1 lb).

It is estimated that the total capital expenditure (CAPEX) and operational expenditure (OPEX) costs for silage production undertaken by a public facility is USD 34 995 if all waste is collected at a central location. At the individual production level, the initial set up cost for silage production is USD 11 800. The production of 100 kg of silage per month was estimated to be between ECD 268.55/USD 424.10 and ECD 725.08/USD1 145.08. All these costs were perceived to be restrictive to the production of silage. At ECD 2.00/USD 0.75 per 0.45 kg (1 lb) or ECD 4.00 for 1 kg, revenue from silage production is estimated to be USD 46 296[1] annually, producing 11 574 kg of silage. However, this price is uncompetitive when compared with current complete feed prices. Feed is subsidized and sold at ECD 35.00 per 22.68 kg or ECD 0.65 for 1 kg.

In Saint Kitts and Nevis there are various supply chain configurations that could be used to produce fish silage. A key advantage in the supply of fish silage is the availability of publicly owned and operated land and building facilities. There is currently a peculiarity with supply and demand that may affect centralized silage production for both islands – more fish are caught and processed in Saint Kitts but more livestock production currently occurs in Nevis. This means that the potential demand for feed additives from fish silage is likely to be higher in Nevis. This peculiarity requires that specific focus be placed on exploring different systems for Saint Kitts and Nevis.

[1] Silage sold at ECD 4 per 1 kg at a production level of 11 574 kg annually.

INTRODUCTION TO FOOD LOSS, WASTE AND FISH SILAGE

In fisheries and aquaculture production, food loss and waste occur at all levels of the value chain for various reasons. Food loss is described as the decrease in quantity or quality of food, while food waste is a part of food loss and is defined as the discarding or alternative (non-food) use of food that was fit for human consumption – by choice or after the food has been left to spoil or expire as a result of negligence. Food loss and waste occur in all areas of the fisheries and aquaculture industries value chain which includes: capture fisheries, aquaculture, processing and storage, wholesale, retail, transport and consumption (FAO, 2019). It was estimated in 2012 that the loss and waste for the whole fisheries sector amounted to 35 percent of global landings and 9 percent to 15 percent of these losses were linked to fish discarded at sea. Annual discards from world fisheries were estimated by FAO to be approximately 20 million tonnes (25 percent) per year (Rustad, 2002). Moreover, in some value chains food loss and waste are estimated to be as high as 70 percent (FAO, 2017). These high levels of loss and waste present a challenge, not only in relation to economic potential not being fully exploited, but the management of fish waste and its environmental impact has become an increasing challenge for the industry.

To minimize the loss and waste produced in the fish and aquaculture value chain, and by extension improve fish waste management strategies, much research has been done to develop methods to convert these wastes into useful products (Perea, *et al*., 1993; Coello *et al*., 2002; Laufenberg, 2003). Similar to waste, value-added products are being created by rest raw material which is the remaining parts of the fish after the edible parts have been removed (Nofimo, 2019). Rest raw material in fish can be viscera, heads, and frames depending on the species. The more popular by-products created are fertilizer and silage. Fish emulsion fertilizer is made by adding fish waste and a sugar ingredient (molasses or brown sugar mixed with a dry ingredient like sawdust) and the mixture is placed in an air tight container to ferment for no less than three months. The production of fertilizer is done by anaerobic processing. Fish silage is a liquid by-product produced from the whole fish or parts of it, to which acids, enzymes or lactic acid-producing bacteria are added, with the liquefaction of the mass provoked by the action of enzymes from the fish (FAO-AFRIS, 2003). Fishmeal is the most abundant animal protein source for the manufacture of rations for domestic animals and silage can be a viable alternative to fishmeal.

BARBADOS

1. National context

1.1 Context of fisheries

Global fish waste production is estimated to amount to between 17.9 million tonnes and 39.5 million tonnes per year, representing an important loss of valuable nutrients (Ramírez, *et al*., 2013). Fish processing for human consumption yields around 40 percent of edible meat, while the remaining 60 percent – composed of bones, skin, head, viscera, meat scraps and scales – are fishery by-products (Gildberg, 1993). In most cases, fishery by-products are considered to be waste and are discarded, causing serious environmental problems and economic losses.

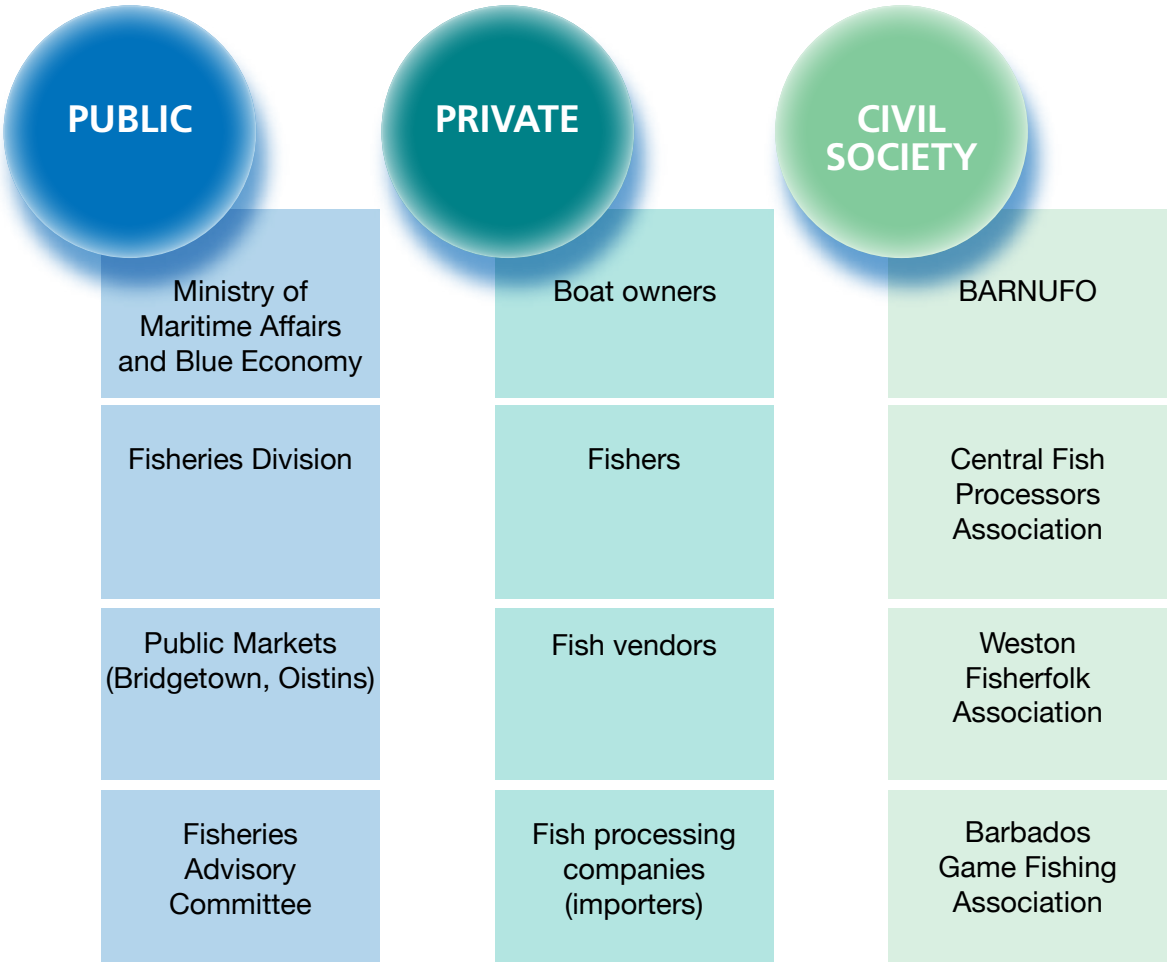
Barbados is the mostly densely populated country in the Caribbean Community (CARICOM), with 659 persons per square kilometre and a total population of 285 000 (World Bank, 2019). The island's economy is heavily dependent on the tourism industry which makes a direct contribution of 12 percent to gross domestic product (GDP) and indirectly contributes approximately 36 percent (World Travel and Tourism Council, 2015). In 2018, Barbados recorded 680 000 long-stay tourist arrivals (Central Bank of Barbados, 2018). In order to meet the dietary demands of the local population and the tourism industry, Barbados imports an estimated 90 percent of the food that is consumed on the island. This makes Barbados a net importer of food and highlights the island's vulnerability as it relates to food security, and by extension sovereignty. Moreover, food imports accounted for 21 percent of merchandise imports in 2016 (World Bank, 2019) totalling over BBD 300 million a year. Fisheries production was estimated at 3 000 tonnes in 2014 and fish imports totalled BBD 44.6 million (FAO, 2016) or 15 percent of food imports. Barbados is therefore also a net importer of fish due to the high demand for fish and seafood products in both the domestic and tourism markets, and the decline in fish landings experienced by the fisheries sector.

On average, Barbadians consume a higher proportion of fish than other nations. Fish consumption in Barbados is 40 kg per person per year, twice the global average of 20 kg per person per day. In addition to consuming fish, fishing is an integral part of the Barbadian way of life and part of the cultural landscape (Parker, 2002). It contributes to the nutritional, economic and social well-being of Barbadians. Fisheries provide a means of livelihood for many people. It is estimated that more than 6 000 people work directly and indirectly in the fishing industry (Mahon *et al*., 2008).

The Barbados fishing industry harvests nine main fish groups: shallow-shelf reef fishes, deep slope fishes, coastal pelagic fish, large pelagic fish, flying fish, sea urchins, turtles, lobsters and conch. The fisheries for flying fish and large pelagic fish dominate the local industry (Fisheries Division, 2007). The status of the stocks ranges from under-exploited to overfished. These fisheries are also highly vulnerable to climate variability and change (Monnereau *et al*., 2015). Climate-related impacts, such as increases in sea surface temperature, ocean acidification and more intense hurricanes, affect the resource base and fishing operations, causing negative impacts across the broader fishery sector, including post-harvest operations, fisheries infrastructure and fishing communities (Monnereau and Oxenford, 2017).

At present, the fisheries sector comprises multiple stakeholders, including those from the private and public sectors and civil society, such as the Fisheries Division, the public fish markets (Bridgetown and Oistins), the owners and operators of fishing vessels, fish vendors and fish processing companies, and civil society (Figure 1).

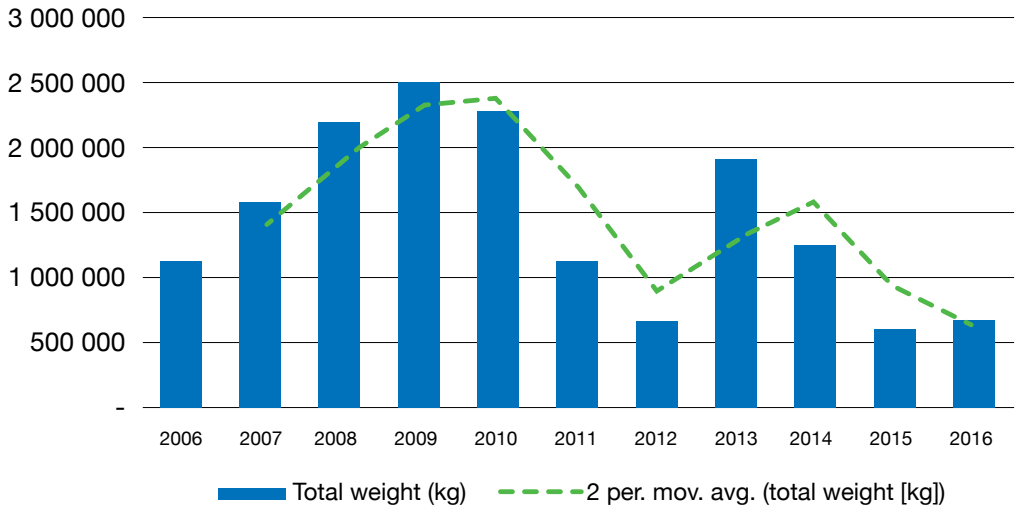
Figure 1
Stakeholders in the Barbados fishing industry



1.2 Fish waste in Barbados

In Barbados there are eight primary fish landing sites, but the majority of catches are landed at the two main fish markets: Bridgetown and Oistins. During the period 2006 to 2016, the average fish landing weight was 1.4 million kg, with the highest landings of 2.4 million kg recorded in 2009 and the lowest landings of 603 720 kg recorded in 2015. During the period under review, fish landings have fluctuated with no clear trend. From 2006 to 2009 landings increased by 120 percent and then declined dramatically by 1.8 million kg or 73 percent in 2012. The sector experienced an exponential increase in 2013 when recorded landings increased by 186 percent. They have been on a steady decrease since then with reported landings by weight 50 percent lower in 2015 and 2016 than they were in 2014 (Figure 2).

Figure 2
Total fish landings 2006 to 2016



Source: Bridgetown Fisheries Market and authors' compilation

In 2015, 603 720 kg of fish was landed. The main fish species caught were dolphinfish (*Coryphaena hippurus*) with 302 831 kg landed representing 50 percent of total landings, followed by flying fish which accounted for 48 percent of total landings. Table 1 provides data on landings by species type and market.

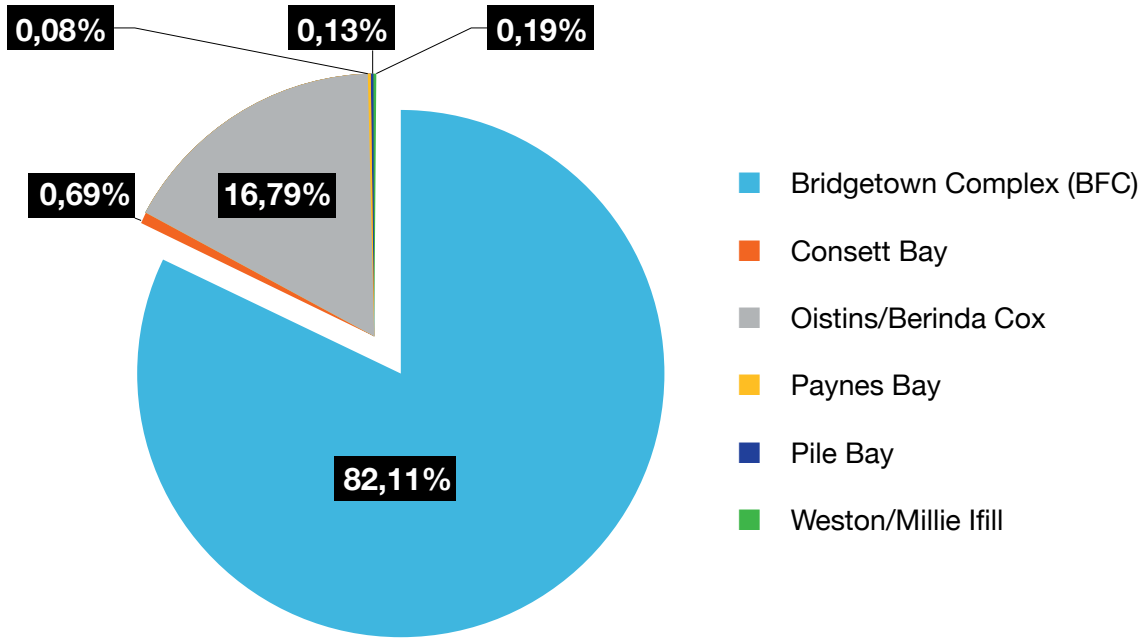
TABLE 1
Fish landings by species 2015

Fish landings	Sum of weight (kg)
Dolphinfish	**302 831**
Bridgetown Complex (BFC)	225 850
Consett Bay	2 691
Oistins/Berinda Cox	73 532
Paynes Bay	371
Pile Bay	144
Weston/Millie Ifill	243
Flying fish	**291 390**
BFC	263 867
Consett Bay	784
Oistins/Berinda Cox	25 364
Paynes Bay	42
Pile Bay	465
Weston/Millie Ifill	868
Kingfish/mackerel	**9 499**
BFC	6 003
Consett Bay	719
Oistins/Berinda Cox	2 471
Paynes Bay	100
Pile Bay	165
Weston/Millie Ifill	41
Grand total	**603 720**

Source: Bridgetown Fisheries Market and authors' compilation

As noted above, the two main markets are the Bridgetown and Oistins fish markets. In 2016, the Bridgetown Fish Market landed 82 percent of total landings, while the Oistins market landed 17 percent of total landings (Figure 3).

Figure 3
Percentage of total landings per market



Source: Bridgetown Fisheries Market and authors' compilation

In 2016, overall landings increased marginally by 71 869 kg or 11 percent compared to 2015. The Bridgetown Fish Market increased its landings by 20 percent to 591 121 kg.

TABLE 2
Total fish landings per market 2016

Landing sites	Sum of weight (kg)
BFC	591 121
Consett Bay	4 685
Oistins/Berinda Cox	78 229
Paynes Bay	600
Pile Bay	198
Weston/Millie Ifill	756
Grand Total	**675 589**

Source: Bridgetown Fisheries Market and authors' compilation

In Barbados, fish waste is generated at two points: (i) the public markets and landing sites; and (ii) private fish processing companies (see Figure 5). In the majority of cases, fish waste is generated and transported to the national landfill. It is estimated that between 2 tonnes and 2.5 tonnes of fish waste are collected from the Bridgetown and Oistins Fish Markets per day during the high season (January to June). This is approximately equivalent to 585[2] tonnes per year.

In addition to this, the private fish processors[3] who participated in this study noted they import approximately 195 000 kg per month, equivalent to 2.34 million kg or 2 340 tonnes per year. The main fish being imported are dolphinfish, billfish/marlin, swordfish, tuna and kingfish.

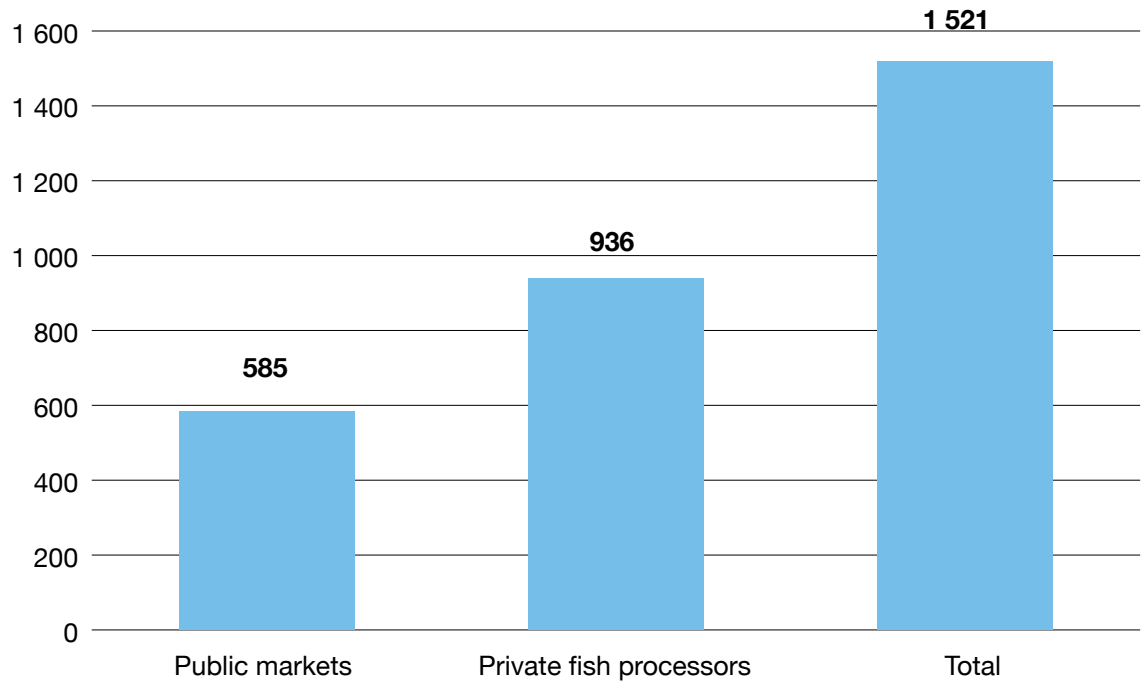
[2] Based on 2.25 tonnes for 260 working days in a year.

[3] Four of the island's main fish processors were involved in the study.

The waste generated by these processors, on average, is estimated to be 40 percent of fish processed, or 78 000 kg per month resulting in 936 000 kg (936 tonnes) per year.

Based on the estimates from both the private fish processors and public markets, Barbados is estimated to produce approximately 1 521 tonnes of fish waste per year (see Figure 4). This is assumed to be an underestimate in some months and an overestimate in others because of the volatility experienced in the fishing industry and fluctuations in demand for fish from the domestic and tourism markets.

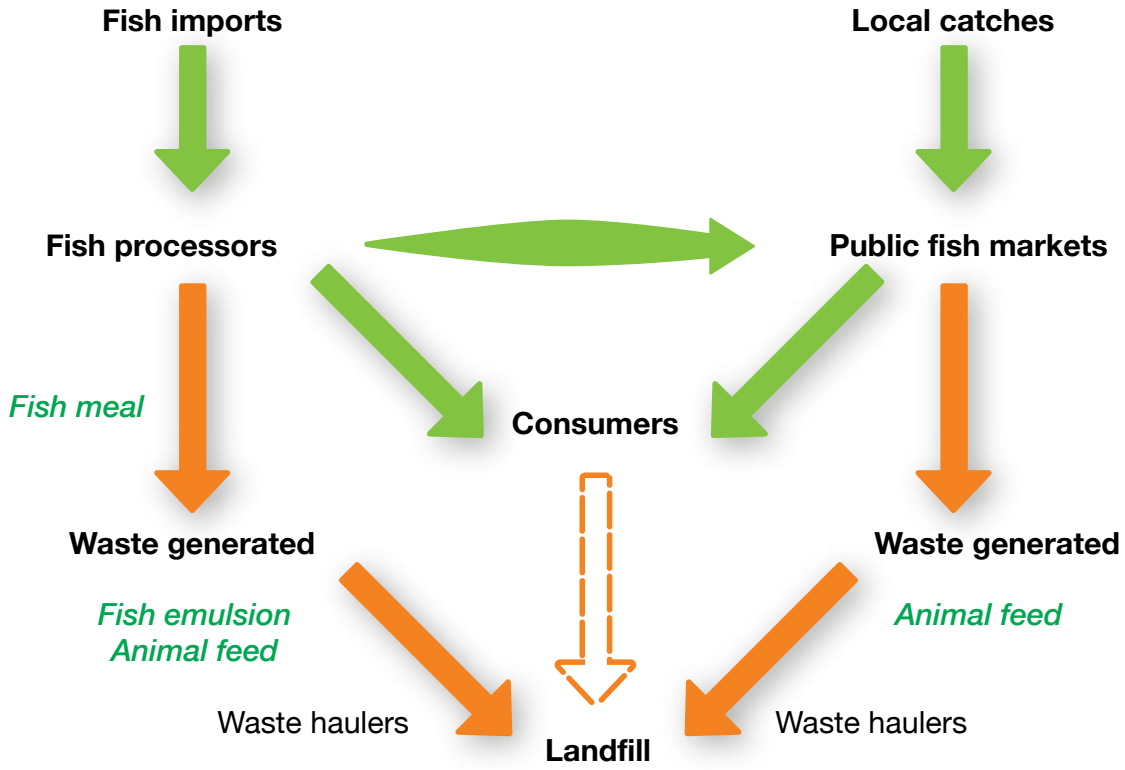
Figure 4
Waste generated (tonnes per annum)



Source: Authors' compilation

Although the waste from the public markets and private processors is discarded at the landfill, private processors noted that they engaged in various waste utilization techniques: (i) creation of fish emulsion that is used as fertilizer for crops; (ii) fish waste is used as animal feed by pig farmers, the Graeme Hall sanctuary for turtle feed and to dog owners for food; and (iii) fishmeal created for value-added products such as fish burgers, fingers, wieners and sausages. Despite the creation of by-products, anecdotal information suggests that approximately 90 percent of the fish waste generated is transported to the landfill (see Figure 5).

Figure 5
Fish waste flow chart



Source: Authors' illustration

Box 1 - Case study of Chickmont Foods Ltd.

Chickmont Foods Ltd. collected fish waste from the Bridgetown Fish Market for approximately two years for the purpose of producing silage, until the operation was no longer profitable. After collection, waste was ground and placed in a pressure cooker for approximately four hours. Nitrates and ammonia (bacteria) were added to help break down the silage mixture and to extract a consumable by-product. The pilot project revealed that by processing 1 000 kg of fish waste, 20 kg of silage was produced. A 2 percent yield was insufficient to cover the labour costs of the truck drivers and market personnel who ensured the waste was collected, sorted and cleaned at the fish market.

One challenge experienced throughout the pilot project was the inclusion in the fish waste of ocean triggerfish, known locally as "turpits", which contain a chemical that is poisonous to poultry. In addition, the silage produced only yielded 1 percent of actual protein. Undoubtedly, this was not an efficient way to produce a quality feed for rearing poultry for a competitive local market. Chickmont Foods Ltd. also engaged in the selling of silage to Roberts Manufacturing Company to be used in the production of pig feed and as a supplement for dog food.

Added to the lack of efficiency in the production process was the risk of harbouring rodents. Staff who worked on the pilot project noted concerns regarding the proper storage and handling of the waste and silage because it is a keen attractor for rodents. The pilot project team also mentioned that if another project was started, time and research in the initial phases should be dedicated to ensuring the protein and quantity yields make it a profitable investment.

2. Methodology

In an effort to investigate the feasibility of the production and utilization of fish silage in Barbados, we employed a mixed method approach which involved both primary and secondary data collection. A literature review was conducted at international, regional, national and sectoral levels to gain an understanding of the fisheries sector generally, existing value chains, fish silage production and past initiatives at the national level. The literature consisted of articles from online journals, books, newspaper articles, reports, conference proceedings and national and regional management plans and protocols. The literature was collected and analysed using thematic analysis by key words including: Eastern Caribbean Fisheries, fish waste generation, fish silage production and value-added products.

Key informant interviews were conducted with fishers, boat owners, fish processors, a representative of the national fisherfolk organization, fisheries management officials, fish market officials, feed producers and a pig farmer. In all, 13 interviews were conducted between 15 March and 5 April 2019 using a semi-structured interview protocol (see Appendix 2) tailored to each stakeholder group. These interviews typically lasted for 45 minutes and were conducted at a place that was convenient for interviewees. In addition to the methods mentioned, a stakeholder validation workshop was also held to cross-check the preliminary information.

Fisheries landing data and trade data were analysed to estimate the amount of fish waste produced monthly. Datasets were procured from the CARICOM Fisheries Information System database hosted by the Barbados Fisheries Division.

To validate the findings, a review and validation exercise was carried out during a silage demonstration four-day workshop held from 23 to 26 July 2019. The workshop was attended by multiple stakeholders, including persons who were involved in the interview process.

3. Market assessment

Fish silage has the potential to be a valuable feed ingredient that can have significant benefits for the agricultural sector in Barbados. As with most organic waste products, silage can be utilized in a variety of ways to aid crop and livestock production. In order to determine the productive uses and assorted benefits that can be derived from the silage industry, an assessment of the current market and existing opportunities must be conducted.

At present, Barbados produces an estimated 1 521 tonnes of fish waste annually, but fish waste products are utilized by a modest cohort of small-scale farmers and the vast majority of the waste is disposed of at the Mangrove Landfill, according to stakeholders. Based on an initial analysis of international trends, fish silage presents a wide range of potential benefits for agricultural producers and associated stakeholders.

3.1 Potential users

Currently there are over 5 000 registered farmers in Barbados, the majority of whom are small-scale crop or livestock producers who farm part-time while engaging in other forms of employment. Demographic data pertaining to farmers could not be obtained at the time of study, but it is known that the number of farmers has been stagnant over the past 10 years, with little to no growth in the number of farmers operating on the island. Trends show that there has been a 19.5 percent increase in the import of livestock products since 2012 (Government of Barbados, 2016). Livestock and dairy production has fluctuated considerably, but average production has declined since 2010. In 2016 the National Agriculture Report highlighted that a large percentage of the decline in livestock production can be attributed to problems with feed quality which was experienced by farmers from late 2014 to the second quarter of 2015. Since then, feed cost and quality have continued to present a significant challenge for local farmers.

Along with crop and livestock producers, there are also some small aquaculture producers in Barbados. Traditionally, freshwater aquaculture has not been a popular option for the Barbadian market because freshwater fish are not the preferred choice of the general public,

but there has been increased interest in the sector over the past five years. There is currently one primary feed supplier for aquaculture producers. Local respondents highlighted that the main commercial fish feed supplier[4] has been able to supply all of the feed for local aquaculture production (excluding the imports of a select group of small-scale producers).

Furthermore, they identified that productivity is restricted by the importation of feed because of low profit margins from local aquaculture products. These low profit margins have resulted in two of the largest aquaculture and aquaponics producers closing over the last five years (Nature's Produce and Archers Aquafarm). Currently, there is one large aquaculture producer and a few small-scale producers, with small “backyard aquaculture” operations continuing to enter the market. Key informants have stated that small-scale production is restricted by high operating costs, including the cost of energy and feed.

There are three primary groups of potential fish silage users:

- crop producers
- livestock producers
- aquaculture producers.

However, there is potential for manufacturing and pharmaceutical groups to play an integral role in the silage industry in the future through additional value-added products for the health and food markets. These products include, but are not limited to:

- fish protein concentrate (FPC) pellets
- fish protein amino acids
- fish oil.

3.2 Agriculture market penetration potential

Agriculture in Barbados is considered to be an aging sector that is dominated by mature practitioners. Fish silage shows potential to reduce the cost of feed in livestock production. However, livestock production in Barbados has not experienced significant technological advances over the past four decades and traditional tools and techniques still dominate the space. The sector has experienced barriers to growth because of the costs of production. There is consensus across all livestock and aquaculture farmers that the cost of feed from local suppliers is restrictive and presents a major barrier to profitability within the agricultural sector. As a result, fish silage inputs have the potential to disrupt the feed market if they can enter at a competitive price point.

In Barbados, livestock feed is regularly sourced from two major suppliers which supply more than 800 tonnes of feed annually. The agricultural sector is primarily made up of small-scale farmers and as a result feed is sold in low volumes per transaction e.g. in 110 kg (50 lb) bags. Individual farmers do not store large quantities of feed and their purchases consist primarily of batches containing 110 kg bags or less at bi-weekly or monthly intervals. As a result, it is suggested that fish silage as a product additive, or in its raw form, must be able to service these long-standing procurement habits. This means that in order to promote the adoption of this alternative feed product, fish silage must either:

- be produced as an independent additive that supplements existing products in order to lower the cost of feed;
- be included in the production of existing feeds as a low-cost alternative to give consumers a wider range of options;
- be made available as an easily accessible resource that can be produced by the farmers themselves.

These three options must take into account the existing market practices and the perceptions of target stakeholders.

[4] Gale’s Agro Products Ltd.

TABLE 3
List of livestock feed suppliers

Feed suppliers	Production (tonnes)
Pinnacle Feeds	640
Atlantic Feeds & Supplies Ltd.	160
Gale's Agro Products Ltd.	66.5
Kings Feed Supplies Variety & Service*	66.5
Hothersal Feed*	66.5
Tweedside Feed Store*	66.5

*These production amounts assume an average production among the four remaining livestock producers

The total quantity of livestock feed utilized by livestock producers in Barbados is currently unknown, but estimates can be made from local production averages. Barbados' largest feed producer, Pinnacle Feeds, currently generates 640 tonnes (1.4 million lbs) per year and the company's production represents approximately 60 percent of the feed utilized in Barbados. As a result, it is estimated that total feed production is approximately 1 066 tonnes (2.35 million lbs) per year.

The cost of feed is segmented by the growth phase of livestock. It ranges from BBD 31.28 for a 25 kg (55 lb) bag of finisher pig feed containing 16 percent protein, to BBD 46.25 for a 25 kg (55 lb) bag of pre-starter pig feed containing 23 percent protein. Therefore, enough fish silage must be generated to supplement the volume of feed being produced and to be price and/or value competitive with protein sources. The average pig farmer spends approximately BBD 180 on feed per sow and BBD 230 on feed per young boar each month. If fish silage can compete with the protein content of soybean and fishmeal, it may have the potential to penetrate the market. Taking this into consideration, it is also noted that wet feed products are not generally used by local livestock farmers and may require additional effort and/or investment for storage if they are to be used as a supplement to other feeds. With most of the farmers having less than 20 units of livestock at any one time, profit margins do not allow for significant investment in new facilities. A sample of local livestock producers stated that, any costs that may be incurred by the introduction of silage products will present a significant burden and must therefore have a two- to four-month payback period if they are to be considered. If fish silage is to be produced locally, it must leverage its high protein content as the primary market advantage. If high protein content additives (at least 44 percent) can be obtained for less than the incremental increase in the cost of existing products, farmers will easily be able to transition to the new product.

Fishmeal and soybean meal are the two main protein sources used in animal feeds. The average international price of fishmeal (65 percent protein) between April 2018 and April 2019 was USD 1 494.81 per tonne, whereas soybean meal (45/46 percent protein) sold for considerably less over the same period, namely USD 386.32 per tonne (Markets Insider, 2019). Therefore, at a minimum, fish silage must be able to compete with soybean meal prices, or at least offer value-add by being a higher protein ingredient.

3.3 Market penetration barriers

Stable quantities

Primary feed producers have highlighted the need for stable quantities of silage to be supplied on a monthly basis in order to meet market demand. However, fish landings fluctuate significantly by type and quantity on a monthly basis. This will therefore require large quantities of silage to be stockpiled to supply local demand. The largest feed producer in Barbados highlighted that unless silage producers can supply at least 53 tonnes per month to substitute their 44 percent crude protein input, it would not be a feasible option.

Stable quality
Key informants highlighted that fish silage would be best utilized as a feed additive to replace the current protein source. Producers currently use soybean as the protein source which keeps a consistent protein percentage. Any additives must keep this percentage so that farmers can add it, in varying quantities, to their starter, grower and finisher feed mixtures. Also, each of these mixtures has a fixed fat source and any fish silage inputs must also be able to maintain fixed fat percentages. Therefore, for existing feed producers to utilize fish waste as an alternative protein source, it must be supplied at a specific quality.

Competitor dominance
Currently, livestock feed suppliers have a significant advantage in the marketplace. They have existing investments in key infrastructure and market relationships to ensure that they are able to meet demand. They have been able to leverage long-standing relationships with larger livestock farmers and governing institutions to maintain dominance. Within this small local market, a select few companies have been able to capture significant market share. Two companies currently provide over 85 percent of locally produced animal feed to the local market[5]. This dominance, combined with the stifled productivity of the local agricultural sector, deters significant investment into commercial feed production by prospective competitors. As a result, the existing feed suppliers have a relatively secure stake in the market and may be targeted as a direct entry point for fish silage utilization.

3.4 Market penetration opportunities

High operating costs
High operating costs have limited the productivity of the agricultural sector and deterred youth from entering the agriculture field. The cost of feed was highlighted as the greatest burden for small-scale farmers by 100 percent of the stakeholders interviewed. However, there have not been any alternative commercial feed options introduced for local farmers in recent years, despite sector-wide dissatisfaction with the cost of feed. This presents an opportunity to service local farmers with a low-cost alternative. Local key informants have highlighted that if fish silage is introduced as a much more affordable (approximately 20 percent lower in price) protein source it may have the potential to outcompete existing dry feed options. For aquaculture production, there are no low-cost feed alternatives currently on the market. As a result, fish silage presents an attractive alternative that may increase profit margins for aquaculture producers.

Agriculture sector development
Development of the agricultural sector is a central mandate of the government of Barbados and strategies to increase food production and modernize the sector are being put in place. This public sector interest suggests that the market can be expected to grow and the door will be opened for innovations and new suppliers to enter the market. However, since demand is limited by market trends and local agriculture producers have not increased production, there is little quantitative basis to support the prospect of substitute feed products or suppliers. Due to this reality, any innovation that can disrupt the current market through the supply of affordable feed alternatives has the potential to encourage livestock farmers to increase production and invite new players into the livestock production market.

[5] Pinnacle Feeds accounts for approximately 60 percent to 70 percent and Atlantic Feeds & Supplies Ltd. accounts for approximately 15 percent to 25 percent.

4. Supply chain review

Fish waste suppliers
The quantity and quality of fish silage that can be supplied to farmers is solely dependent on the quantity, freshness and type of fish waste collected. The organizations and individuals that currently produce fish waste include:

Primary sources
- fish markets and landing sites
- fish processing companies.

Secondary sources
- individual fish hawkers

4.1 Waste sorting
In order to produce high quality fish silage, the by-product and waste utilized must be of a high quality. At present, waste is primarily generated from two sources. Waste generated at private fish processing plants can be easily sorted to accommodate the handling of raw materials such as heads, viscera and frames. However, at public markets the sorting and retention of fish by-products and waste after processing is negligible. To be efficient and optimize the value of fish waste as an input to the production of fish silage and to rationalize waste streams, three key areas must be supported:

1 Education and sensitization of workers in the public fish markets about the benefits of sorting waste correctly.
2 The appropriate infrastructure and resources (colour coded bins, “how to” infographic guides, covered skips and security) to support good sorting practices.
3 The hiring of sorting officers who have direct responsibility for handling and sorting of waste generated in the public markets.

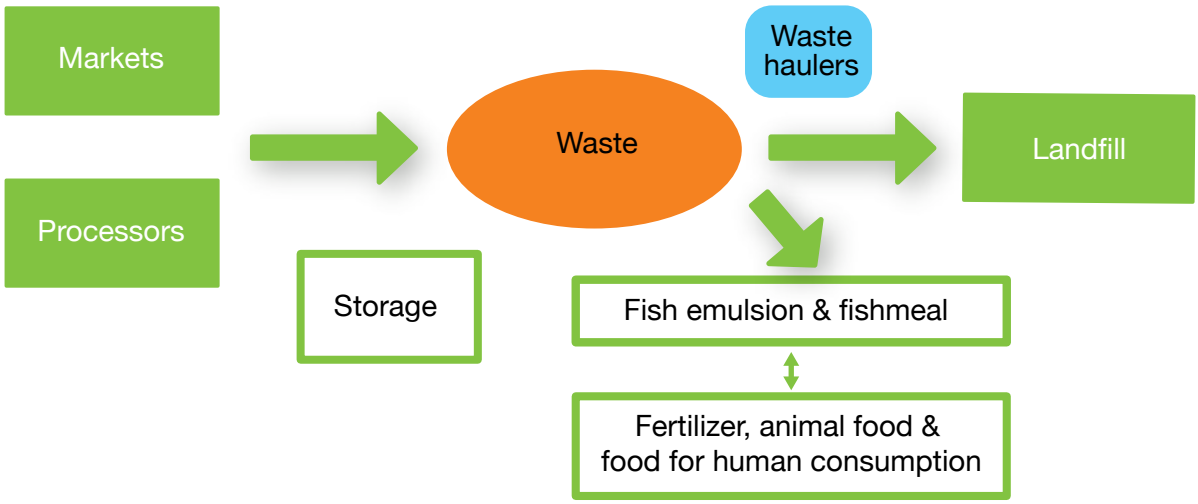
Developing an organized sorting procedure allows for the improved management of raw materials and other by-products, e.g. offal, the rationalization of waste streams and the opportunity to produce value-added products such as fish silage, compost and leather, etc.

4.2 Supply chain scenarios
Based on the study results, a number of possible supply chain scenarios have been developed to assess the infrastructural and supply chain needs of fish silage production and utilization in Barbados. The different scenarios are discussed next.

4.2.1 Scenario A
Scenario A (Figure 6) presents the current scenario with respect to the ways in which fish waste is generated and disposed of. At present, fish waste is generated from the public markets, landing sites and by private fish processors. Fish waste is collected daily by private waste haulers from the two main fish markets because there is no onsite storage facility for waste. Waste is separated into two streams: fish offal and municipal waste, and then transported to the country’s main landfill operated by the Sanitation Service Authority (SSA). The fish offal waste is treated and managed separately at the landfill but no value-added by-product is created.

Some private fish processors are creating value from fish waste on a small scale. One processor is currently storing and turning their waste into fish emulsion which is then sold to a farm that uses the emulsion as fertilizer. Other processors discard their fish waste by giving it away to private individuals and nature sanctuaries for animal feed. One processor utilizes fish by-products to create fishmeal which is then used in fish-based burgers, sausages and patties. Any waste which is not utilized for by-products at processing facilities is discarded, hauled by private haulers and discarded at the landfill.

Figure 6
Scenario A – existing supply chain



Advantages of Scenario A
In scenario A the landfill is a central collection point for fish waste. Participants in the study noted that converting fish waste, either at the landfill or at a recycling facility, into compost to make fertilizer is a low-cost, high impact proposition. Therefore, Scenario A presents a supply chain configuration for which very little adaptation would have to be made to turn fish waste into a product for resale.

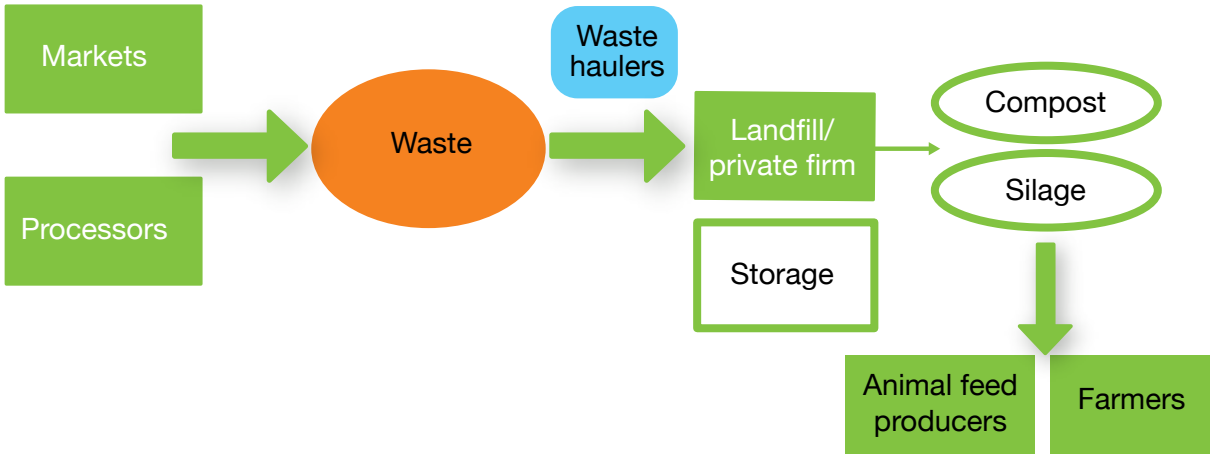
Limitations of Scenario A
The current scenario has two main limitations: storage capacity and very little utilization of waste. Given that the public markets do not have the capacity to store the waste, or the financial resources to acquire it for resale purposes, waste collection is the only viable option. The volume of waste generated at present is too large to be stored at the market. Also, the rate at which the waste breaks down (two to three days using chemical acids and up to seven days using biological alternatives such as molasses) must be taken into account when considering storage. The only storage facility available at the Bridgetown Fish Market is the chill room which is used for dry storage. If the chill room is utilized for silage storage, then an alternative arrangement would need to be made for dry storage.

The majority of fish waste is discarded at the landfill with only small-scale, value-added waste pilot projects being undertaken. Therefore, a large proportion of waste is being dumped. In addition to these two major constraints, there are problems related to securing the waste at the public markets. Here, waste skips are utilized for a variety of items and waste sorting techniques are poor. Waste sorting is also an important factor in creating different waste streams and there should be some rationalization of waste. This lack of sorting would affect the quality of the waste being produced for silage.

4.2.2 Scenario B

To take advantage of the current supply chain (Scenario A) participants noted that a low investment, high impact alternative could be the creation of a production and storage facility at either the Mangrove landfill or a private recycling facility such as the Sustainable Barbados Recycling Centre (SBRC) to produce fish silage. This adaptation within the supply chain requires little investment or logistical changes to the existing supply chain. It is also proposed that a system could be created in the landfill whereby cells are solely used for the creation of compost, rather than silage, by simply mixing soil with fish, other animal by-products and vegetable matter. Utilizing fish waste to create compost material is seen as a more viable alternative to silage production. In this configuration, represented in Figure 7, the SSA is able to expend a minimum amount of resources to make a new product (compost and/or silage), which can be sold to the market.

Figure 7
Scenario B



Advantages of Scenario B

With scenario B there is little financial and infrastructural input required which makes this a cost-effective scenario. Integrating a separate storage facility into the supply chain allows for a central point for the collection of fish waste. This would allow for a central unit being directly responsible for the collection and storage of the waste. The creation of composting material can be done within the existing framework and the SSA could have a product that could assist with revenue streams for the public entity. The staff at the fish markets noted they had a high level of willingness to participate in this type of scenario.

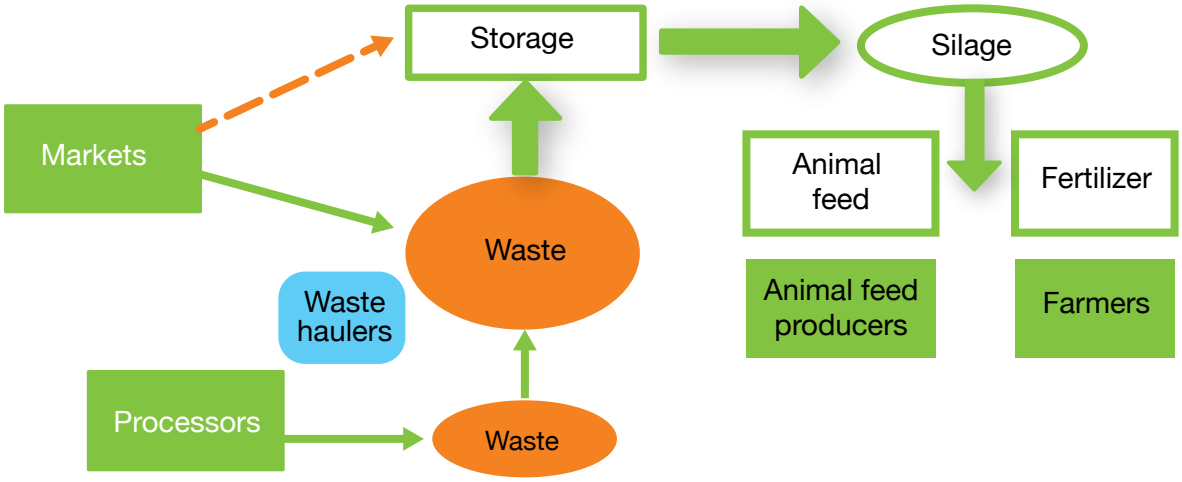
Limitations of Scenario B

The limitation of this scenario is the payment for the waste and the transportation of the waste so that it may be used to create a by-product. A payment scheme between the fish market and the SSA would have to be established in order for this scenario to be viable.

4.2.3 Scenario C

Figure 8 provides a schematic representation of another possible supply chain configuration. Scenario C assumes the public markets are responsible for the production and storage of fish waste. Private fish processors would have to pay waste haulers to deliver waste to the market and a pricing scheme would have to be explored to determine their willingness to sell their waste. A major consideration for this approach is the hiring of personnel to sort and maintain waste at the markets, because currently waste is poorly sorted and the market does not have the human resources to dedicate to such activities.

Figure 8
Scenario C



Advantages of Scenario C

Scenario C allows for fish waste and the production of silage to be managed by the public sector, with the advantage that it could generate a new source of revenue for the public markets. Also, by placing the production and sale of fish silage within the public markets, the health and safety risk associated with the production process and storage could be managed by the quality control officers who are already working there. This arrangement is also an opportunity for vendors and processors to increase their revenues by actively participating in the enhancement of the fisheries value chain.

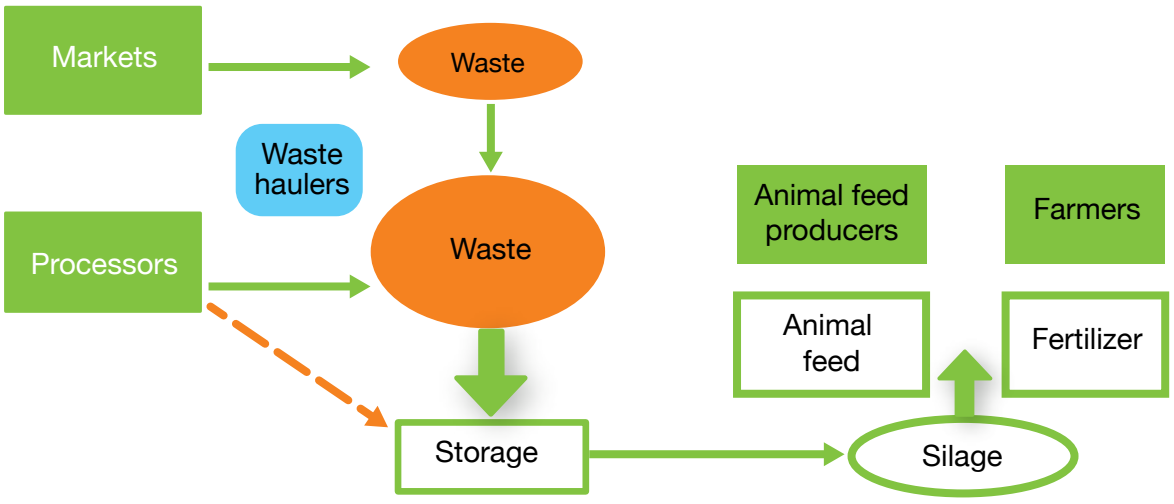
Limitations of Scenario C

In this supply chain, the public markets are central to production. Fish offal and other waste is disposed of free of charge, therefore it may be difficult to ask vendors and processors to sort waste without providing an incentive. Even if an incentive is devised, vendors and processors may not be interested in sorting their waste, as this may be viewed as an added activity to their operations, with little reward. The critical component of the success of this scenario is the hiring of persons who are solely responsible for the sorting of waste to ensure that waste is rationalized and various waste streams (skins, offal, fish oils, etc.) are captured and utilized. Another concern raised in scenario C was the poor track record of publicly managed buildings and facilities and that if fish silage production is managed and maintained by public markets there would be a low chance of success.

4.2.4 Scenario D

This scenario, represented by Figure 9, proposes that fish waste is transported to a privately-run facility such as a fish processing plant. Private actors have expressed a willingness to act as a central point of collection and storage in order to produce by-products such as fish silage to be used as fertilizer and/or animal feed. This scenario may offer greater efficiency because private firms would be motivated to optimize production processes and seek returns on their investment. This is a potential win–win scenario because profitability would be linked to closing the waste cycle, creating a circular sector.

Figure 9
Scenario D



Advantages of Scenario D

Scenario D allows private businesses to participate in a waste management solution by creating value-added products such as silage. Encouraging private investors to engage in developing a sustainable solution to an environmental problem is a best practice model for creating a circular economy where the value of products and materials is maintained for as long as possible. It is expected that in this scenario waste and resource use are minimized, and when a product

(in this instance fish) reaches the end of its life, it is used again to create further value. This can bring major economic benefits, and contribute to innovation, growth and job creation. Local private businesses expressed a strong interest in this type of configuration.

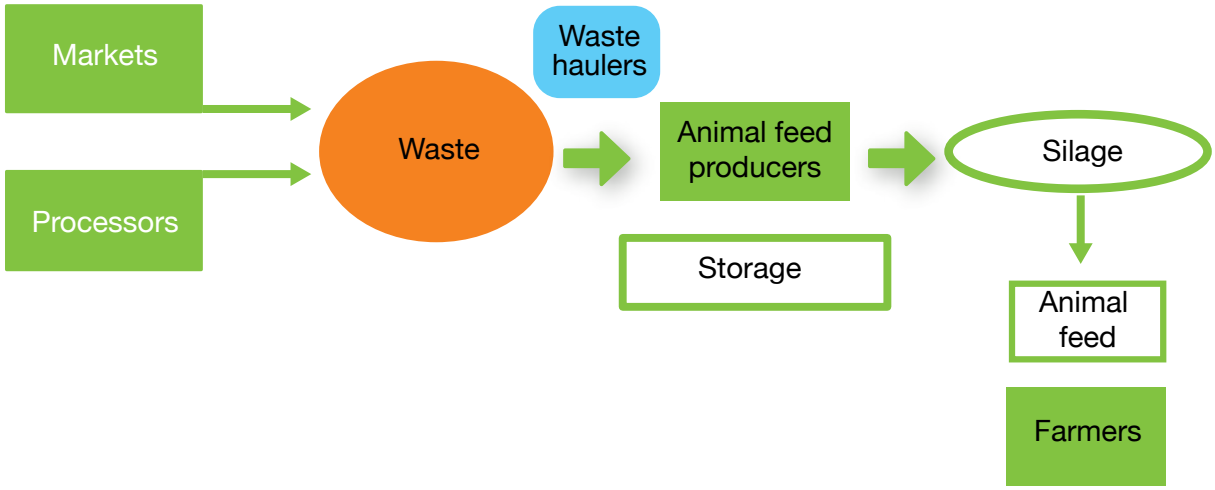
Limitations of Scenario D

In order for scenario D to be effective, the payment scheme for fish silage from the public markets and other processors would have to be determined. This may prove challenging because a fair negotiation would have to be reached in order for fish vendors and processors to feel as though they are benefitting from the value being created rather than being exploited. The transportation of waste, and which actor is responsible for this activity, is another area in the supply chain that would have to be formalized to ensure that when waste is generated it is transported to the storage facility for efficient processing. Delays in waste hauling could have an impact not only on the quantity of by-product that may be produced, but also the quality of the product; any delays in processing could affect the quality of the waste which then impacts the quality of the silage.

4.2.5 Scenario E

Scenario E (Figure 10) is one in which the local feed producers are responsible for the storage of fish waste and production of fish silage. This supply chain places the fish waste directly into an existing production facility. By doing this, the process benefits from existing infrastructure and logistics in the production of animal feed. Fish waste can be transformed into fish silage to supplement the protein included in animal feed. In doing so, depending on volume and consistency, fish silage could reduce the dependency of feed producers on imported protein additives such as soybean. Establishing fish silage production in the domestic animal feed market could potentially reduce the cost of feed to farmers which is a cost saving that could then be passed down to consumers.

Figure 10
Scenario E



Advantages of Scenario E

Scenario E proposes an opportunity to streamline fish waste into the local production of animal feed. This is advantageous because cost savings can be passed down through the supply chain and, because of its integration into an existing production process, economies of scale can be exploited to reduce prices for famers and consumers.

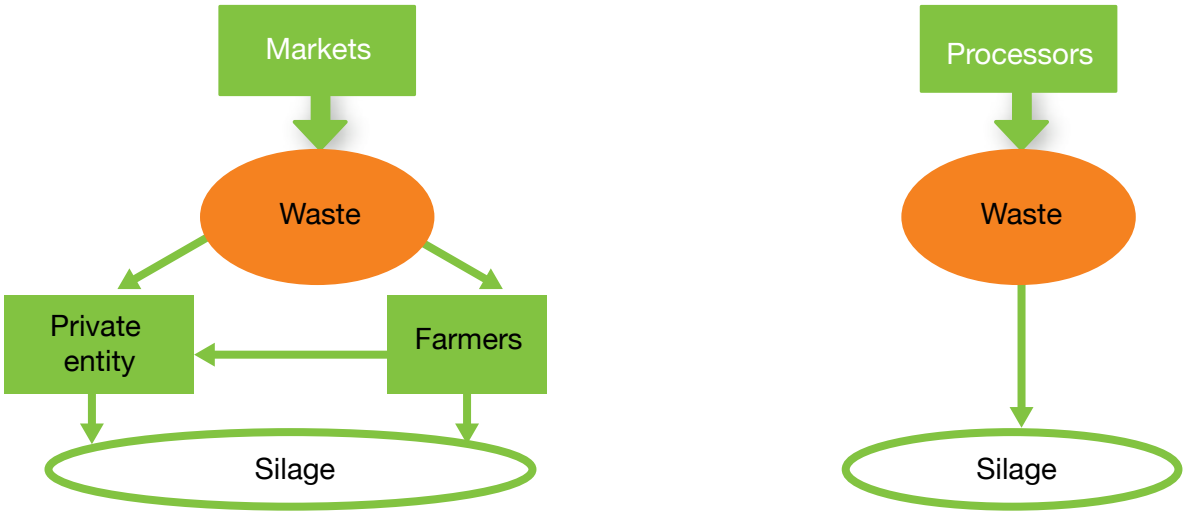
Limitations of Scenario E

Feed producers acquire food safety and quality certifications and introducing fish silage production into existing storage facilities and production processes could compromise these certifications. Supplementing soybean protein, which is in a solid state, with fish silage which is in a semi-solid state, could also prove challenging in the production process. Animal feed producers also noted concerns which could apply to the entire production of fish silage – the potential lack of consistency in terms of supply availability as the fish landings and types of fish vary by season.

4.2.6 Scenario F

Scenario F (Figure 11) is based on the feedback and validation of the participants in the fish silage demonstration workshop. The participants reviewed Scenarios A to E and recommended the below scenario which has elements taken from each of the aforementioned scenarios.

Figure 11
Scenario F



Scenario F is a merger of centralized and decentralized production of silage. In this scenario, the public markets provide a private entity or individual farmers with fish waste which is then converted into silage and used as a fertilizer or a component of animal feed. Farmers also have the option of buying waste from the private entity. In addition, working independently are fish processors who convert their waste to silage for use primarily as fertilizer. The staff of the public markets noted it is more efficient for one entity to collect the waste from the market, rather than multiple persons doing so.

5. Financial assessment

5.1 Capital and operational expenditure estimates

The financing required for the production of fish silage in the Barbadian context is directly related to the type of supply chain configuration that is implemented. Regardless of the type of configuration selected, there are standard capital and operating expenditures (CAPEX and OPEX) that will be required if waste is collected at a centralized location and silage produced. The expenditure identified in Table 4 is aligned with those presented in Blanc and Le-Bars (2009) where fish silage equipment requirements were outlined, and Forbes and Sumner (1992) where the economic feasibility of fish silage production was investigated in Australia. The expenditure detailed below is the standard expenditure expected to be incurred if fish silage production is undertaken, and it is acknowledged that other costs[6] could be incurred. Therefore, this study highlights the main CAPEX and OPEX of fish silage production.

[6] Other costs refers to costs such as taxes, duties and utilities (water and electricity).

TABLE 4
Capital and operating expenditure for fish silage production

CAPEX and OPEX items	Assumptions
	CAPEX
Land	Land could be considered a capital expenditure. Many stakeholders noted storage would be a challenge for producing silage. The leasing of land could be considered.
Building	Similar to land, the rental of a building may be required for the production and storage of silage. Rental rates for agro-processing/factory facilities are approximately USD 6 per 0.56 m^2 (1 ft^2).
Grinder (industrial)	An industrial grinder would be appropriate if production occurs on a large scale at either the fish market, fish processors or feed producers. Electric industrial grinders range in price from USD 650 to USD 20 000 for a fishmeal rendering processing line, inclusive of grinder.
Grinder (individual)	Small-scale meat grinders could be utilized if production occurs at the fish vendor and/or the farmer level. Meat grinders range in price from a minimum of USD 20 to a maximum of USD 300.
Pump	Fish silage production on a large scale will require the silage to be pumped from the grinder to other holding containers. The capacity of the pump would be determined by the volume of silage being produced daily. Industrial pumps range in price from USD 100 to USD 1 000.
Testing equipment	The price of a pH meter ranges from a minimum of USD 20 to a maximum of USD 250. A more cost-effective testing instrument is litmus paper which costs USD 3 to USD 25 for a package of 75 to 100.
Mixing tank	Mixing tanks come in various sizes and materials. Given that the total estimated fish waste produced daily could be approximately 5 tonnes[7], a chemical stainless steel mixing tank that has the capacity to hold approximately 5 678 litres (1 500 gallons) is priced between USD 25 000 and USD 35 000.
Storage tank	Similar to the mixing tank, storage tanks would have to be installed and the volume of waste collected and the silage produced would determine the size of the tanks. Here it is assumed that two to three storage tanks of an approximate 3 028 litre (800 gallon) capacity would be sufficient. These tanks range in price from USD 10 000 to USD 30 000.
Vacuum truck	To deliver the silage to feed producers a vacuum truck may be required. Used vacuum trucks (2013) are sold online for approximately USD 32 000.
	OPEX
Labour (4)	If production takes place within the fish market, it is expected that at least two staff members will be required to sort the waste for processing. Private processors also noted that if they received a large volume of waste they would have to hire staff to handle the production of silage. If production occurs at a designated site, at least four staff members would be needed: two general workers, one administrative officer and one supervisor. USD 175 to USD 250 a week for general workers; USD 1 250 for an administrative officer and USD 1 500 for a supervisor.
Waste services (skip & transportation)	The transportation of fish waste at present is USD 6 per day for an 8 m^3 skip and USD 55 per trip for removal.

[7] This daily total is arrived at by summing the private and public waste collected and dividing by 30.

The CAPEX and OPEX that are calculated in Table 5 are based on the following assumptions:

1. There is no existing infrastructure to produce the silage;
2. The public markets are the actors responsible for the production of fish silage at an offsite facility;
3. The waste being produced is 5 tonnes per day;
4. The cost estimates are reflective of year one of operation and do not account for year on year expenditures such as depreciation of assets; and
5. Fish silage is sold directly to feed producers.

TABLE 5
Estimates of capital and operating expenditure

Expenditure	USD	Notes
Land	150.00	It is assumed that government provides land and building facilities to produce the silage.
Building	30 000.00	Building rental is based on USD 6 per 0.56 m^2 (1 ft^2) offered by BIDC for factory spaces.
Grinder (industrial)	20 000.00	An industrial grinder would be required under this scenario.
Pump	1 000.00	It is assumed a minimum of one industrial pump is needed for production.
Mixing tank	30 000.00	The cost of a mixing tank represents the average cost of a 5 678 litres (1 500 gallons) chemical mixing stainless steel tank.
Storage tank (2)	40 000.00	The storage tank cost is estimated at the average of cost of a 3 028 litre (800 gallon) stainless steel tank.
Testing equipment	250.00	It is assumed a minimum of one electronic pH tester is needed.
Vacuum truck	32 000.00	A 2013 Mitsubishi Fuso canter vacuum truck with a holding tank of 3 700 litres.
Total CAPEX	**153 400.00**	
Labour	55 100.00	The cost of labour is based on four staff members (two general workers, one supervisor and one administrative officer): general workers – USD 212.50 per week, administrative officer – USD 1 250 per month, supervisor – USD 1 500 per month.
Waste services	57 420.00	This cost is based on the removal of fish offal daily for 261 working days in a year from four sites: two public markets and two private fish processors.
Total OPEX	**112 520.00**	
Total cost	**265 920.00**	

The total cost to set up a fish silage production facility with a production capacity of 1 521 tonnes of fish waste collected annually, at a yield rate of 1 368 tonnes of fish silage is USD 265 920. This is under the assumption that all costs, both capital and operating costs, are incurred in the first year of operation. In addition, formic acid, a key component of silage production, costs USD 1 500 for a minimum quantity of 35 kg, is excluded from the above calculation. The organic substitute for formic acid is molasses, which is available at USD 1 per 3.78 litres (1 gallon). Table 6 provides costs for various acids that may be used in the production of fish silage and which are available in Barbados. The total estimated cost also attributes no cost to fish waste, but this is a tenuous assumption because once waste is no longer discarded at the landfill but used as a raw material a value will be attached to it.

TABLE 6
Cost of acids for fish silage production

Acid	Amount (kg)	Cost USD	Local supplier
Sulfuric	102 (drum)	271.50	Massy Distribution
Acetic	30 (liquid)	134.50	Massy Distribution
Formic	35	1500.00	Collins Pharmacy

Stakeholders who participated in the fish silage demonstration workshop also contributed towards estimating fish silage production at the individual, small-scale level. The costs associated with producing a 100 kg of silage per month are outlined in Table 7.

TABLE 7
Fish silage production cost at the individual level

Cost of silage production						**For 100 kg or 10 kg/day**	
Cost		**Items**	**Units**		**BBD**	**Chemical**	**Biological**
Operational		Fish waste	BBD/100 kg		BBD 10/kg	BBD 10.00	BBD 10.00
		Waste transport	BBD/100 kg		BBD 35.00	BBD 35.00	BBD 35.00
	Electric cost	Meat grinder	hr/100 kg	BBD/KWH	BBD 0.58/kw	BBD 31.90	BBD 31.90
	Chemical	Formic acid	kg/100 kg	BBD/kg	BBD 67.5/kg	BBD 1 350.00	BBD 60.00
	Employees	Production	BBD/100 kg			BBD 300.00	BBD 300.00
	Cleaning	Detergent & other cleaners			BBD 40.00	BBD 40.00	BBD 40.00
Fixed	Electric energy	Whole space	Hr/100 kg	BBD/KWH	BBD 1.58	BBD 1.58	BBD 1.58
	Water		BBD/100 kg	BBD/month	BBD 30.00	BBD 30.00	BBD 30.00
Total cost			BBD/100 kg			**BBD 1 798.48 USD 899.24**	**BBD 508.48 USD 254.24**

The estimated cost of producing 100 kg of silage per month is USD 899.24 using the chemical method, and USD 254.24 using the biological method. These estimates suggest that individual famers can produce biological silage considerably cheaper than the chemical silage. Also, workshop participants indicated that biological silage production presents a potentially cost-effective alternative to fertilizer and an animal feed component. In addition, the estimated cost in this scenario is BBD 10.00 per 100 kg or BBD 0.10 per kg. This estimate was garnered from fishers in the Bridgetown market who after consultation were unsure of this cost and a definitive cost for waste could not be determined.

5.2 Revenue estimates

Based on the cost of fishmeal and soymeal on international markets, it is assumed that fish silage could be sold at these prices to the local feed producers. Table 8 provides the sales revenues.

TABLE 8
Revenue estimates

Price per tonne	Units (t)	Total sales revenue
USD 1 494.81 (fishmeal)	1 368	USD 2 044 900.08
USD 386.32 (soybean meal)	1 368	USD 528 485.76

The above cost and revenue estimates show that the production of 1 368 tonnes of fish silage at a minimum cost of USD 265 920, would generate revenue (based on competitive prices) from USD 528 485 to USD2 044 900. Based on these estimates, fish silage production *ceterus parabus* is feasible in Barbados. Table 9 shows the annual operating surplus for the first year.

TABLE 9
Annual operating surplus (soybean price)

Sales revenue			**USD 528 485.76**
	Units (t)	1 368	
	Price	USD 386.32	
Total cost			**USD 265 911.84**
	OPEX	USD 82.25	USD 112 518.00
	CAPEX	USD 112.13	USD 153 393.84
Annual operating surplus			**USD 262 573.92**

Annual operating surplus using the price point of soybean meal (USD 386.32) totals USD 262 573.92. However, these estimates do not include the cost of acid, a central ingredient for fish silage production. The annual operating surplus, including the cost of formic acid, shows a loss of USD1 692 990.08 (Table 10).

TABLE 10
Annual operating surplus (soybean price & formic acid)

Sales revenue			**USD 528 485.76**
	Units (t)	1 368	
	Price	USD 386.32	
Total cost			**USD 2 221 475.84**
	OPEX	USD 82.25	USD 112 518.00
	Formic acid	USD 42 857.00[8]	USD 1 955 564.00
	CAPEX	USD 112.13	USD 153 393.84
Annual operating surplus			**USD (1 692 990.08)**

The above estimates utilize the price of soybean meal to calculate sales revenue. Sales revenue can also be calculated using fishmeal prices. These estimates are provided in Table 11.

TABLE 11
Annual operating surplus (fishmeal price & formic acid)

Sales revenue			**USD 2 044 900.08**
	Units (t)	1 368	
	Price	USD 1 494.81	
Total cost			**USD 2 221 475.84**
	OPEX	USD 82.25	USD 112 518.00
	Formic acid	USD 42 857.00	USD 1 955 564.00
	CAPEX	USD 112.13	USD 153 393.84
Annual operating surplus			**USD (176 575.76)**

[8] Based on 3 percent (w/w) of 1 521 tonnes of fish waste @ cost of USD 42 857 per tonne.

Fish silage production can also be produced using biological agents such as molasses as an alternative to chemical acids. These financial estimates are provided in Appendix 1.

5.3 Financial institutions

There are a number of financing options that can be used by potential investors. These options include a mix of private and public finance.

Private financing mainly comes from:

- commercial banks
- credit unions.

Public financing mechanisms

- Barbados Investment Fund
- fund access
- trust loans
- Youth Entrepreneurship Scheme and Enterprise Growth Fund, etc.

In addition to the traditional avenues of private and public financing, a more innovative and equitable option could be the formation of a fisheries/farmers' cooperative society that is financially oriented and increases equity among fishers and farmers. The cooperative could be the financing mechanism used to set up fish silage production in which both fishers and farmers have a vested financial interest while contributing to a sustainable, circular sector.

6. Organizational assessment

In the proposed configurations for the production and utilization of fish silage in Barbados (see Section 4 – Supply chain) the various actors identified (i.e. public, private, quasi-government, and public-private partnership) can be broadly classified into three sectors: (i) fisheries, (ii) waste management, and (iii) agriculture. Thus, it is expected that the implementation of any configuration will overlap these sectors. An organizational assessment for the facilitation of fish silage production and utilization should consider the above-mentioned sectors, with an emphasis on the regulatory environment and the preparedness of key actors. This cross-cutting assessment is needed to determine the necessary considerations that should be made to promote the cooperative and effective handling of fish offal across said configurations.

6.1 Enabling environment: fisheries

In Barbados, the Ministry of Maritime Affairs and the Blue Economy (MMABE) is primarily responsible for the fisheries sector through the Barbados Fisheries Division (BFD). The BFD, whose mission is to ensure the optimum utilization of the fisheries resources in the waters of Barbados for the benefit of the people of Barbados through management and development, is one of three departments that fall under the purview of the MMABE. Key actors in fisheries include the minister responsible for fisheries (i.e. minister of the MMABE), fisheries officers (e.g. chief fisheries officer), the Fisheries Advisory Committee (FAC), fishers, fish vendors, fish processors and other stakeholders (e.g. Barbados National Union of Fisherfolk Organizations [BARNUFO], research institutions and non-governmental organizations, NGOs).

The extensive fisheries network comprises numerous actors with the skills and resources to suitably fill the fishery-related roles in the proposed configurations – as is evidenced by the current production of fish emulsion by a private fish processor. Moreover, personnel such as quality control officers in the BFD are trained to provide the necessary quality control/quality assurance support which is needed in the latter part of the process of producing fish silage. The MMABE has endorsed the utilization of fish offal for other innovative and beneficial uses, such as the production of fish silage. However, none of the actors in this network are specifically mandated to recover fish offal or generate fish silage. The roles and responsibilities of key actors are laid out in the Fisheries Act.

The Fisheries Act (Cap 391) is the principal legislation that governs fisheries in Barbados. Enacted in 1993 and amended in 2000, the Fisheries Act addresses an array of issues, inclusive of the provision of fisheries management and development, which has allowed several regulations to be drafted and enacted from the parent act. However, there is no direct mention in the Act, nor in the associated national regulations such as the Fisheries (Management) Regulations (1998), Draft Fisheries (Operations) Regulations, the Draft Fish Quality and Inspection Act, and the Marine Pollution Control Act (1998), of the handling of fish waste or the production of fish silage. Nonetheless, it follows that the Fisheries Act allows for the incorporation of international agreements to inform policy and management. In this way, FAO's CCRF and other major fisheries-related international instruments are utilized by the FAC and other local entities as guiding principles in fisheries management.

A few of the principles found in the CCRF encourage the production of fish silage:

- use of post-harvest practices that maintain nutritional value and quality of products;
- conduct trade in fish and fishery products according to applicable agreements.

A critical tool endorsed by the CCRF is the formulation of a fishery management plan (FMP) as a strategic and tactical instrument for planning and operational management in fisheries. The Fisheries Act gives legal authority for a FMP, and thus Barbados has produced the following iterations: 2000 FMP, 2001 to 2003 FMP and 2004 to 2006 FMP. The FMPs were compiled with contributions from a wide spread of government and non-governmental stakeholders. They were examined by the FAC, reviewed by the public and approved by the minister of MMABE. Other instruments, such as the Caribbean Community Common Fisheries Policy (CCCFP) that was crafted by the Caribbean Regional Fisheries Mechanism of which Barbados is an active Member State, is a regional fisheries policy that supports collaboration between all stakeholders for the sustainable utilization of fisheries and related ecosystems in the Caribbean. In spite of the allowances made in the CCRF and CCCFP, local instruments still lack the promotion of recovered products from fish offal.

6.2 Enabling environment: waste management

In Barbados, the Ministry of the Environment and National Beautification (MENB) (formerly known as the Ministry of Environment and Drainage [MED]) is mandated "to promote and facilitate the sustainable use of the nation's resources by encouraging the involvement of all citizens and the integration of environmental considerations into all aspects of national development" (Government of Barbados, 2019). Key actors in waste management from the proposed configurations in Section 4 – Supply chain, include the SSA, SBRC, and private waste haulers.

The contribution of the key actors in waste management to the proposed configurations consists of collecting, transporting, sorting, and dumping of fish waste at the public landfill. The collective resources that currently exist among these entities are sufficient to support the handling and disposal of fish waste, although a more efficient sorting system is warranted. Furthermore, the making of compost is feasible given that minimal resources are needed and at present there is an area of land designated for such a purpose at the landfill. Despite the apparent ease of accessing resources and the ongoing execution of present roles, none of these actors is mandated to manage fish waste, besides the SSA that deals solely with its disposal.

The mandate of the SSA is detailed in the Sanitation Service Authority Act (1975) which repealed and replaced the Sanitation and Cemeteries Board Act of 1969. The Sanitation Service Authority Act speaks solely to waste management from the standpoint of the disposal of municipal waste and the maintenance of public spaces. Organic wastes such as fish offal are not mentioned in the Act; nor are the various types of wastes differentiated. In 2015, a collaborative research effort was made by the MED of Barbados, Inter-American Development Bank and Export-Import Bank of Korea to improve the process of collection and management of solid waste in Barbados, and to enhance route optimization. However, this research focused heavily on residential waste, with minor emphasis placed on industrial waste and no consideration given to other types of wastes.

6.3 Enabling environment: agriculture

In Barbados, the Ministry of Agriculture and Food Security is mandated to promote an agri-business approach to farming, with particular attention paid to the effective use of resources and the sustainable management of the natural resource base of the country. Key actors in agriculture, as it relates to the utilization of fish silage, include animal feed and fertilizer producers, farmers, and the chief agricultural officer. The roles of producers and farmers in the proposed configurations are specifically end-users of the fish silage; the chief agricultural officer will play a role in the registration and regulation of such products.

The Fertilisers and Feeding Stuffs Act addresses the registration, sale and consignment of fertilizers and feeding stuffs (where "feeding stuff" means any article which is intended for consumption by livestock and purporting to supply proteins, carbohydrates, fats, minerals, condiments, or vitamins, and includes any article prepared for the purpose of preventing or correcting nutritional disorders). The Act does not apply to all types of fertilizers, such as compost, fish and fish waste, but clearance and permission may have to be sought for the use of fish silage in, or as, animal feed.

6.4 Challenges and considerations

The organizational assessment of the sectors of fisheries, waste management, and agriculture revealed a moderately robust legal framework and a supportive network of actors across the sectors. Nevertheless, existing policy instruments do not directly define the roles and responsibilities of key actors. Nor do they address aspects of market and institutional arrangements regarding the handling of fish waste for the production of fish silage, despite provisions made by the Fisheries Act and the CCRF. The absence of such regulations can constrain and challenge the successful implementation of fish silage production. Moreover, given the lack of legal sanctions and the cross-cutting nature of fish silage for fisheries, waste management, and agriculture, thought must be given to disputes that will likely arise over the ownership of fish waste, incentives for contributions, privatization, apportioning of revenue, and access to and costs of fish silage.

7. Barriers and recommendations

In this feasibility study of the production and utilization of fish silage in Barbados, all factors relevant to the successful implementation of this innovative post-harvest practice were evaluated. The assessments of the market, supply chains, finances and organizational structures revealed several limitations. These limitations, along with recommendations and proposed actions, are detailed in the following subsections.

7.1 Barriers

Challenges that could impede the implementation of a fish silage industry in Barbados, and a few shortcomings identified by this study are listed here.

- A consistent supply of fish waste and fish by-products is needed to meet the monthly market demand for fish silage. It is estimated that the minimum quantity required is 53 tonnes, to substitute the required 44 percent crude protein input that is used on average by the largest feed producer in Barbados.
- Local livestock farmers stated their preference for dry feed products compared to wet feed products. The use of wet feed products may incur additional effort and costs to store, therefore the most feasible use of silage is as an input to dry animal feed products, as a protein source.
- The cost of formic acid presents a challenge to the financial feasibility of silage production. Formic acid increases the operating cost by more than 500 percent. This presents a significant challenge for the production of silage. Alternatives, whether chemical or biological, should be explored.

- Stakeholders throughout the study noted the production of compost may be more feasible than the production of silage. Composting requires fewer changes to the supply chain and requires less financial and infrastructural investment for start-up.
- Existing policy instruments and sectoral management plans do not define the roles and responsibilities of key actors, nor do they address aspects of market and institutional arrangements regarding the handling of fish waste and the production, sale and utilization of fish silage.

7.2 Recommendations

The following recommendations should be taken into consideration:

- Due to the high nutritional content of fish silage and concerns about fish silage being used in finisher feed, it is recommended that fish silage be primarily used in starter pig feed. Using fish silage in finisher feed raises concerns about the quality of meat produced, particularly in pigs;
- Due to the simple process of creating silage that can directly be used as fertilizer, stakeholders registered an interest in the use of silage as crop fertilizer, rather than as an ingredient in animal feed.
- The establishment of a fisheries/farmers' cooperative society that is financially driven could be an innovative option for a funding mechanism.
- The allocation of publicly-owned resources towards the production set up, particularly land and buildings, could offset the cost of start-up.
- Policy instruments and management plans should explicitly define the roles and responsibilities for the various actors involved in the prospective handling of fish offal and the production of fish silage, and also set rules and regulations for market arrangements and product standards.
- A FMP is a good mechanism to set out the considerations for the production of fish silage.
- Line ministries and organizations such as MMABE, BARNUFO and FAO, etc. should be prepared to engage with and empower key actors through training that uses best available practices and supports capacity building and knowledge sharing.
- The FAC is a centralized committee that can assess and recommend the most suitable configuration for facilitating fish silage production, given that most of the key actors are represented on the committee. Although the FAC mostly consists of members who function solely in the fisheries sector, formalized memberships were extended to a representative from the Markets Division (i.e. the entity responsible for all public markets, including the fishing facilities) and a representative of the MENB (McConney, Mahon and Oxenford, 2003). Consideration may need to be given to the appointment of a representative to the FAC to act on behalf of the private sector and fish processors. (NB. allowance for this is made in the Fisheries Act. The chief fisheries officer can appoint four other persons engaged in the fishing industry to sit on the FAC).

SAINT KITTS AND NEVIS

1. National context

1.1 Context of fisheries

Global fish waste production is estimated to amount to between 17.9 million tonnes and 39.5 million tonnes per year, representing an important loss of valuable nutrients (Ramírez, *et al*., 2013). Fish processing for human consumption yields around 40 percent of edible meat, while the remaining 60 percent – composed of bones, skin, head, viscera, meat scraps and scales – are fishery by-products (Gildberg, 1993). In most cases, fishery by-products are considered to be waste and are discarded, causing serious environmental problems and economic losses.

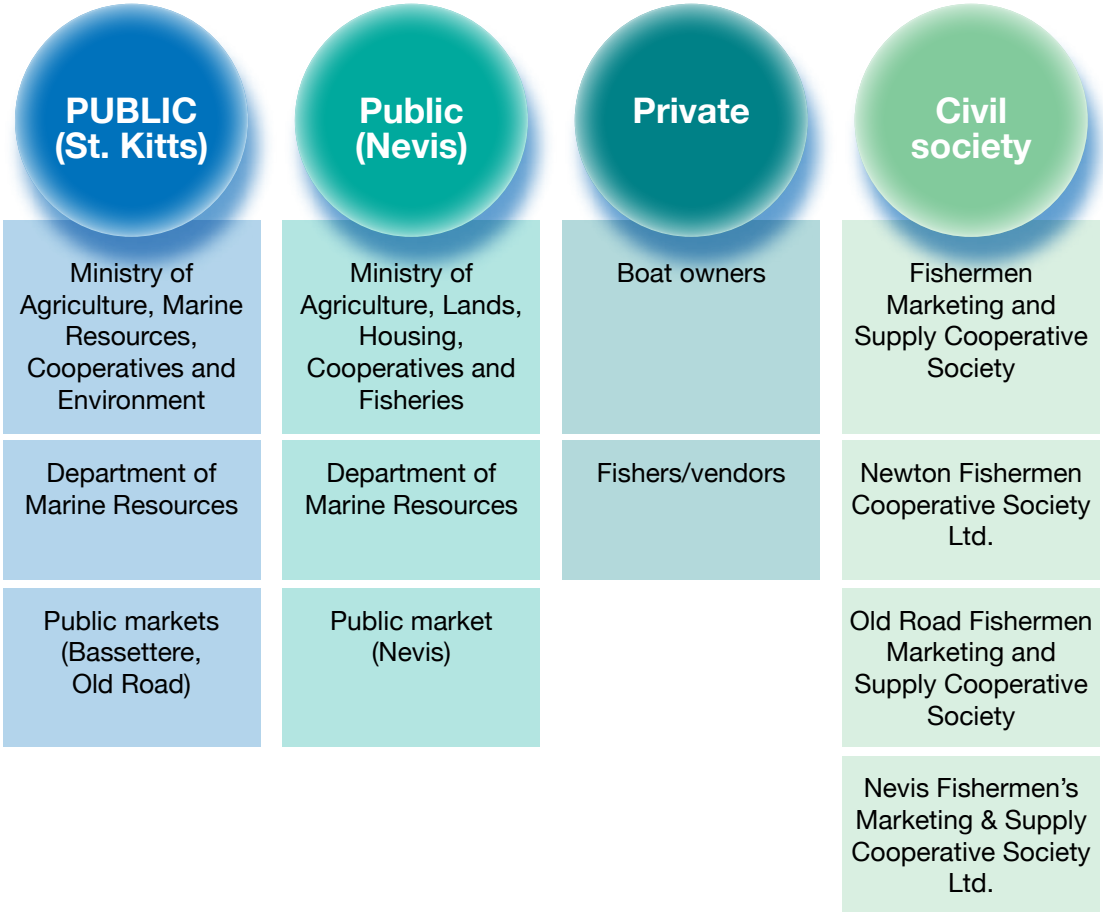
Saint Kitts and Nevis are two Caribbean islands located in the Caribbean Sea with a total area of 261 km^2 and a coastline of 135 km. These volcanic islands are separated by The Narrows, a 3 km wide channel and a territorial sea of 12 nautical miles. Also, Saint Kitts and Nevis has an exclusive economic zone of 200 nautical miles. The fisheries sector represented 0.5 percent of GDP in 2014 and is estimated to employ about 805 persons (FAO, 2016). In 2018, total fisheries landings were 412 485 kg (Department of Marine Resources, 2019).

The islands monitor four main fisheries: the demersal or reef/bank fishery, the coastal pelagic fishery, the ocean pelagic fishery and the conch fishery (The Commonwealth Network, 2019). There are nine landing sites across the two islands and of the registered 260 vessels, more than 75 percent are involved in the demersal reef fishery which utilizes traps, hand lines and spear guns. A total of 802 persons were reported to be engaged in fishing, representing approximately 4 percent of persons employed on the island. Three persons are actively employed in aquaculture and 24 women are engaged in the marine and coastal fishing sector. In 2019, Nevis fisheries officials recorded 450 registered fishers. A small coastal pelagic fishery operates in shallow waters using seines and occasionally gillnets and accounts for a substantive portion of the catches (about 40 percent) of reef fishes and small pelagic fish. Saint Kitts and Nevis has a small and highly seasonal ocean pelagic fishery which utilizes the same vessels used for the reef fisheries, and deploys trolling lines to catch dolphinfish, tuna and mackerels (FAO, 2016).

In 2016, with the objective of better managing fish stocks and the overall health of the marine environment, the Department for Marine Resources (DMR) established marine managed areas (MMAs) two miles off each island and is now in the process of zoning these areas. Fisherfolk were at first resistant to the marine protected areas, but once DMR indicated it would be a managed area, fisherfolk were more cooperative and understood the benefits that MMAs would have for the fisheries sector.

At present, the fisheries sector has numerous stakeholders from the private and public sector and civil society including: the DMR, the main fisheries complexes at Basseterre, Old Road and Nevis, owners and operators of fishing vessels, fish vendors and civil society. Figure 12 below is a schematic representation of the stakeholders in the sector.

Figure 12
Stakeholders in the fisheries sector: Saint Kitts and Nevis

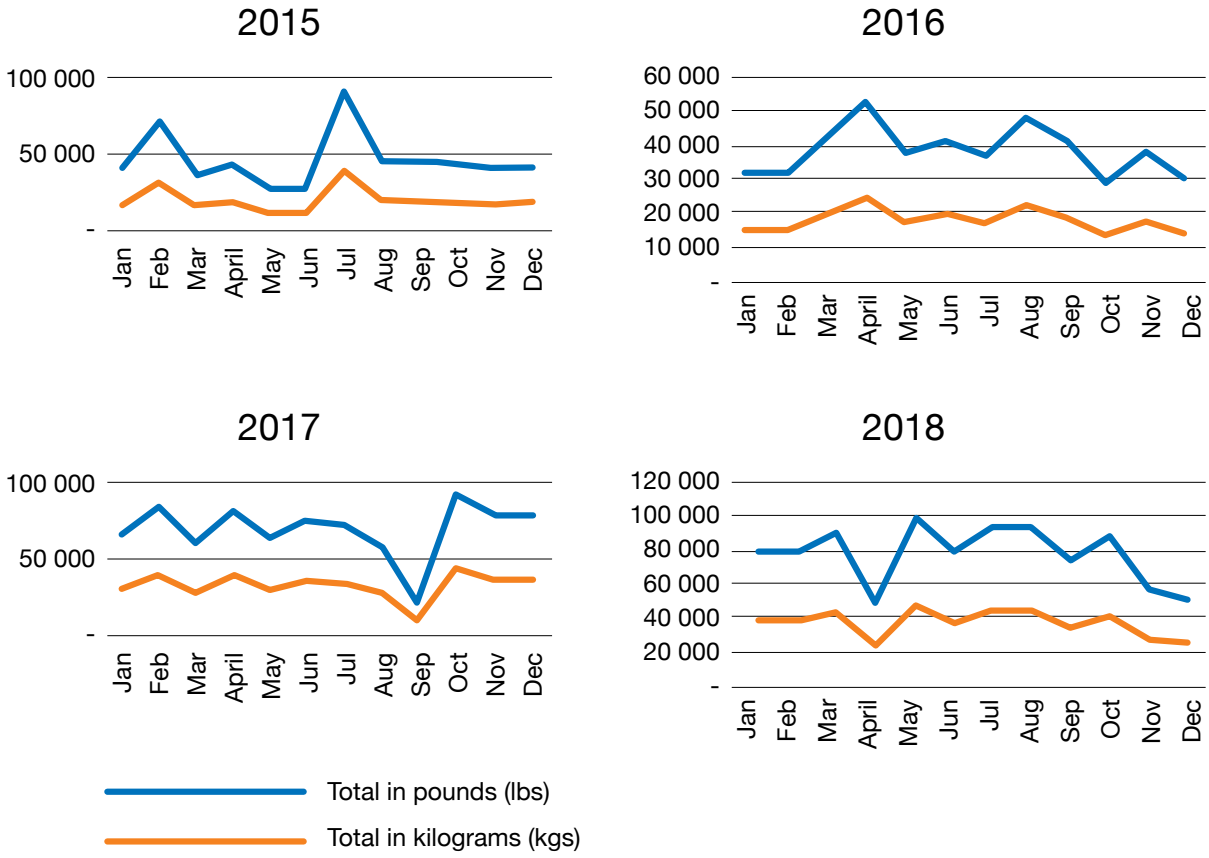


1.2 Fish production and waste

1.2.1 Fish landing and production

In the last 10 years the DMR has made data collection a key priority. The monthly data obtained for landings does not follow any specific trend, despite stakeholders noting that fish catches are lower during the months of November to February due to colder waters and rougher seas. In 2015, fish landings were at their highest in the months of February and July; in 2016 the highest recorded landings were in April and August; and in 2017 the months of February, April and October recorded the highest fish landings, with a noticeably sharp decline in September, possibly due to the passage of Category 5 hurricanes Maria and Irma. In 2018, landings peaked in the month of May.

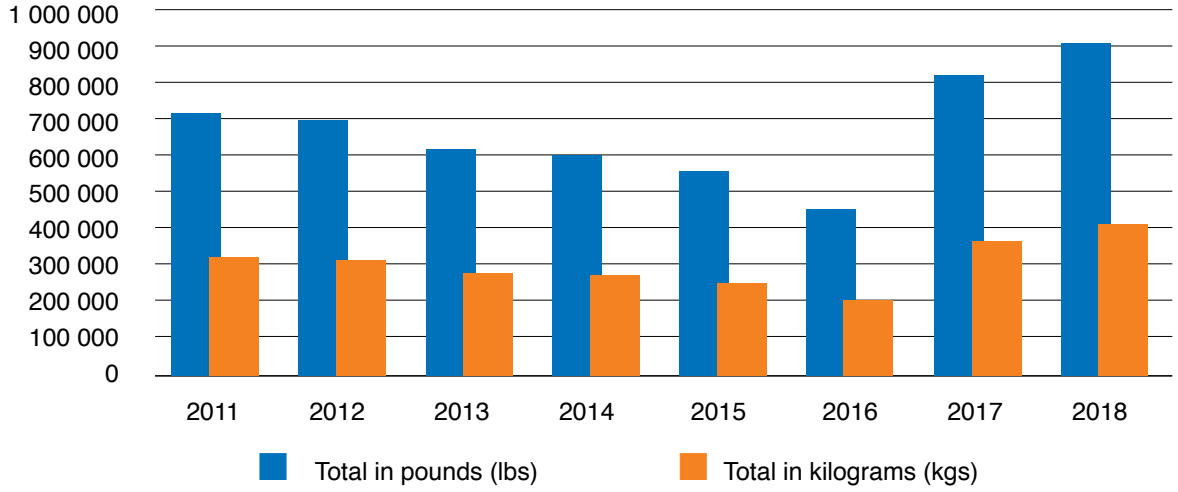
Figure 13
Fish landings (2015 to 2018)



Source: DMR; authors' compilation

From 2011 to 2018, total landings fluctuated. From 2011 to 2016 landings decreased by 115 702 kg (36 percent) but since 2016, fish landings rapidly increased from 208 563 kg to 412 495 kg in 2018, an increase of 97 percent (Figure 14).

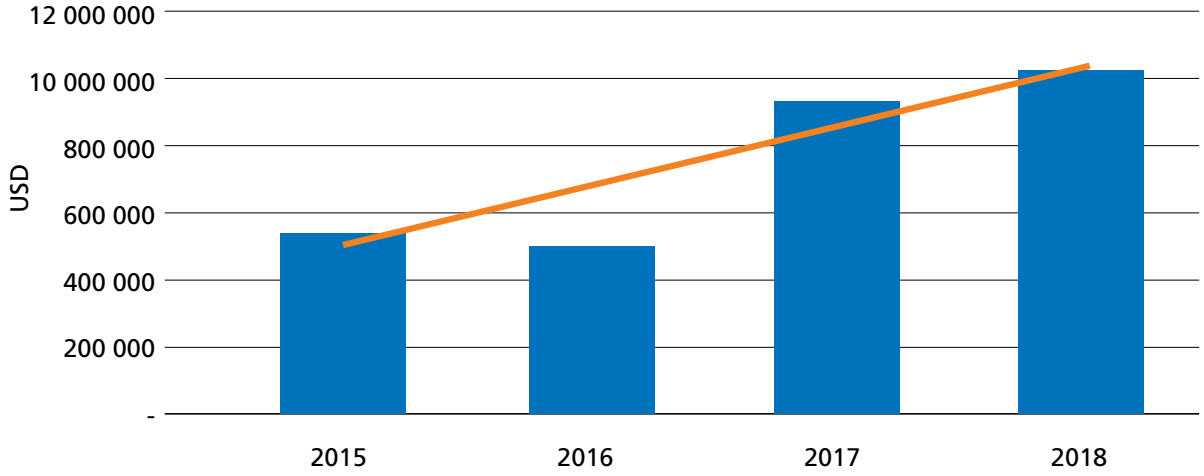
Figure 14
Annual fish landings (2011 to 2018)



Source: DMR; authors' compilation

Given the rise in the volume of landings, the value of the sector also increased during the period 2015 to 2018. The total value of the sector rose from ECD 5.4 million in 2015 to ECD 10.2 million in 2018, an increase of 88 percent (Figure 15).

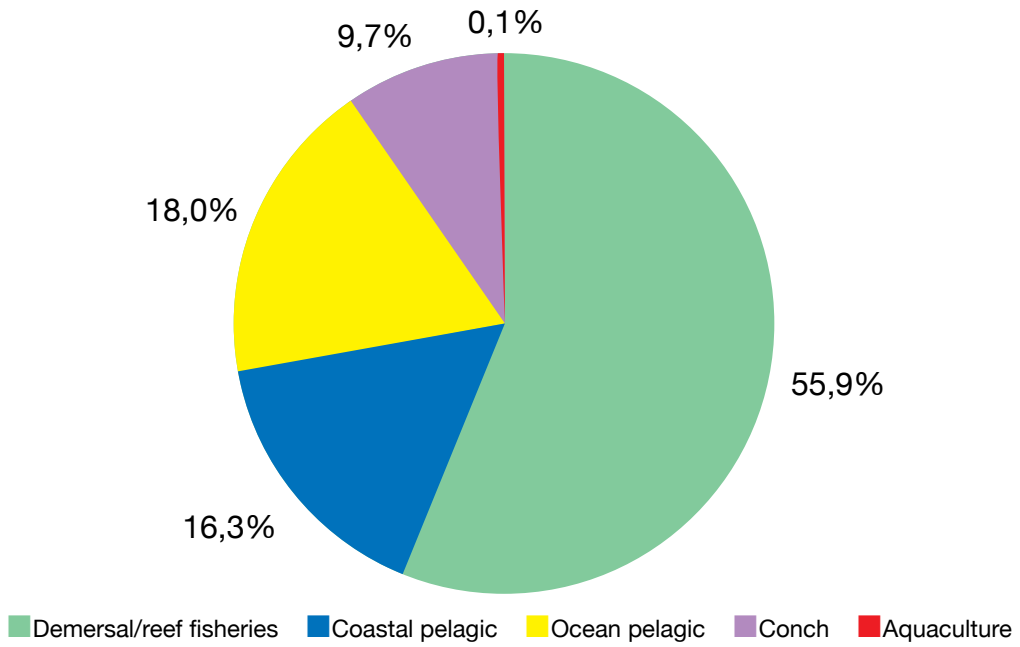
Figure 15
Total value of landed fisheries



Source: DMR; authors' compilation

In 2018, demersal/reef fisheries accounted for 55 percent of the total fish landed. Snapper (Lutjanidae) and grouper (Serranidae) were the top two species groups caught, with landings of 78 040 kg and 74 230 kg, respectively. The ocean pelagic species group accounted for 18 percent of total landings and consisted mainly of landings of dolphinfish (*Coryphaena hippurus*) 82 490 kg and tuna/mackerel (*Thunnus/Scombridae*) 48 110 kg. Coastal pelagic fish accounted for 16.3 percent of landings and consisted mainly of gars (Belonidae) and jacks (Carangidae). Conch and aquaculture production represented less than 10 percent of fisheries production (Figure 16).

Figure 16
Percentage of fish landings per species group (2018)



Source: DMR; authors' compilation

1.2.2 Fish waste

In Saint Kitts and Nevis there is a cultural practice of discarding fish offal at sea, particularly for larger ocean pelagic species such as tuna and dolphin. Fishers are trained to gut fish at sea and

place the fish on ice until the boats have landed. At the artisanal level it is common practice for fishers to gut and process fish on the coastline and discard the waste in the nearshore area. The pelagic fish waste that is generated at the fisheries complex consists mainly of fins and heads (although fish heads are also sold to customers), while some reef fish will generate waste, including offal, heads and fins.

Basseterre Fisheries Complex

The Basseterre Fisheries Complex (BFC) falls under the management of the DMR and has 12 staff members, of whom two are fish processing officers. Stakeholders noted the main fish sold at BFC were pot fish (snapper, butterfish, and hind, etc.), with a value of ECD 17 per 0.45 kg (1 lb). In 2019 there was a reduction in catches of pelagic fish. It was noted that pot fish produces the most waste. Traditionally, any waste generated at the complex is thrown into the sea using 19 litre (5 gallon) buckets (See Plate 1). The stakeholders interviewed at BFC stated they have limited knowledge of the potential of fisheries by-products and they expressed a keen willingness to learn new ways of utilising waste.

PLATE 1
Fish processing at BFC

PLATE 2
Fish processing at BFC

Old Road Fisheries Complex

At present 10 boats supply the Old Road Fisheries Complex (OFC) with fish and, as stated, all of these vessels gut their catch at sea. The waste that is generated by processing within the facility is also discarded at sea or given to local farmers to be used as a deterrent to monkeys on farms. During the peak season OFC lands approximately 1 360 kg (3 000 lbs) of fish per week. It was noted that the waste generated from processing fish inclusive of gutting ranged from 0.45 kg (1 lb) to 1.13 kg (2.5 lbs) per 4.53 kg (10 lbs) of fish, depending on the species. Despite the practice of gutting at sea, OFC's supervisor noted they are willing to accommodate the disposal of fish waste on site for further processing once the necessary standards are put in place.

PLATE 3
Area identified at OFC to store fish waste and silage

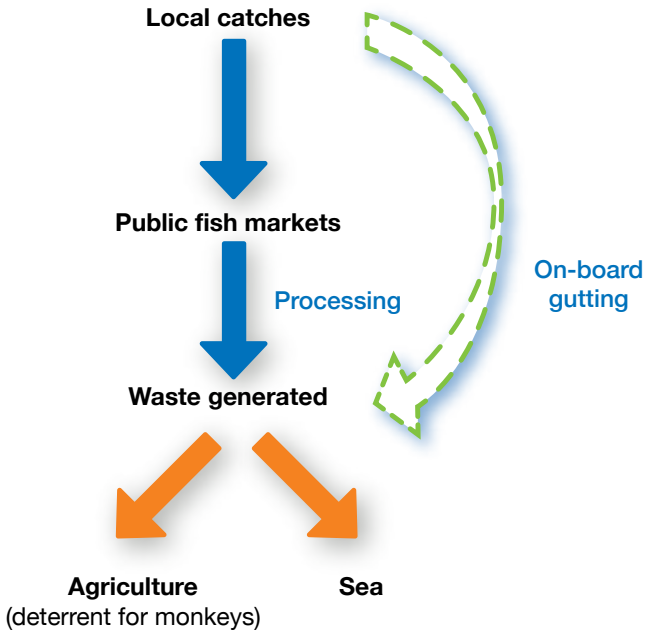
Nevis Fisheries Complex

The fish processing and waste disposal activities that take place at the Nevis Fisheries Complex (NFC) are very similar to those at BFC and OFC. During the peak season, NFC collects approximately 226 kg of fish. Key informants in Nevis noted that currently species are cleaned separately and therefore any sorting which may need to be undertaken in order to utilize waste could be done without any major challenges.

Although fisherfolk have access to locker facilities and are able to sell their fish directly to the government managed complexes, many either process their catch themselves or use private processors who then discard the waste generated in the nearshore area. In addition, any estimate for waste generation is likely to be underestimated because waste from hotels and restaurants is excluded from this study; waste is mixed with other municipal waste and sent to the landfill. Fish imported by hotels and restaurants is pre-processed.

Figure 17 outlines where and how waste is generated and disposed of in Saint Kitts and Nevis. Local catches are the main source of waste generated, with on-board gutting being the primary method of discarding fish waste. Waste primarily ends up in the sea, with very few crop famers utilising fish waste in an ad hoc manner.

Figure 17
Fish waste chart flow



Source: Authors' illustration

For the purposes of this study, fish waste volumes are calculated by using two methods based on information received from key informants. Due to fish offal being discarded at sea, the total weight of fish caught is not recorded, only the weight of fish landed is recorded. Taking this limitation into account, the calculations used were: (i) a standard rate of waste from processing is applied to the total fish landed, and (ii) the ratio of waste by species type is based on key information provided by informants.

Method 1

Using fish landing data from 2011 to 2018, a standard 20 percent ratio[9] is applied to represent waste generated from processing. Between 2011 and 2018, an average of 273 000 kg (670 000 lbs) of fish were caught each year in Saint Kitts and Nevis. The amount of waste that is generated varies according to the species of fish, but it can be estimated that at least 20 percent of the fish caught will be discarded as fish waste. Therefore, approximately 55 880 kg (5 tonnes)/121 000 lbs of waste is generated annually.

Method 2

Using the main categories of fish caught in Saint Kitts and Nevis the following ratios and subsequent estimates for waste are determined, based on every 4.5 kg (10 lbs) of fish.

TABLE 12
Fish waste ratios

Fish species	Fish weight (kg)	Waste (lbs)	Ratio
Demersal/reef fisheries	4.5	0.45	0.10
Coastal pelagic	4.5	1.125	0.25
Ocean pelagic	4.5	1.125	0.25

[9] This is based on some key informants noting approximately 20 percent of the fish caught is discarded as waste.

Key informants noted that for every 4.5kg (10 lbs) of fish caught, fish waste represents a minimum of 0.45 kg (1 lb) and up to 1.125 kg (2.5 lbs) of the catch. It was noted that reef fish generated waste at the lower bound, while coastal and ocean pelagic fish generated waste at the upper bound. Since gutting is done at sea, the following estimates for waste are calculated on weight landed, which does not include fish with viscera. This is a major limitation in the calculation of waste but no other data are available. Future data collection which records fish weight inclusive of viscera is imperative as it would allow improve the accuracy of waste estimations.

TABLE 13
Estimates of fish waste (2018)

Fish species	Total fish landed (kg)	Waste ratio (kg)	Fish waste (kg)
Reef fisheries	50 746	0.10	5 074
Coastal pelagics	14 836	0.25	3 709
Ocean pelagics	16 310	0.25	4 077
Total	81 892		12 860

Based on the landing data of 2018, fish waste is estimated to be 12 860 kg, or approximately 13 tonnes. As noted previously, this is an underestimate because it does not include fish viscera, which are discarded at sea, nor does it include fish waste from hotels and restaurants which is discarded with other forms of municipal waste.

The two methods employed highlight the lack of accurate fish capture weight data vs the landed weight data that is utilized for the purpose of the study. The discrepancy of 55 tonnes vs 13 tonnes further reiterates the need for accurate fish capture data to provide more robust estimates of total waste generated by the sector.

2. Methodology

In an effort to investigate the feasibility of the production and utilization of fish silage in Saint Kitts and Nevis, we employed a mixed method approach which involved both primary and secondary data collection. A literature review was conducted at the international, regional, national and sectoral levels to gain an understanding of the fisheries sector generally, existing value chains, fish silage production and past initiatives at the national level. The literature consisted of articles from online journals, books, newspaper articles, reports, conference proceedings and national and regional management plans and protocols. The literature was collected and analysed using thematic analysis by key words including: Eastern Caribbean fisheries, fish waste generation, fish silage production and value-added products.

Key informant interviews were conducted with fishers, boat owners, fisheries management officials, staff at the fisheries complexes, pig farmers and an aquaculture farmer/researcher. A total of 12 interviews were conducted using a semi-structured interview protocol (see Appendix 2) tailored to each stakeholder group. These interviews typically lasted for 45 minutes and were conducted at a place convenient for the interviewees. Appendix 3 provides the mission schedule with the names of persons who participated in the interviews. A sensitization workshop was conducted with interviewees after the interview period to further garner information and to validate the information generated by the interviews.

3. Market assessment

Like many other small island Caribbean territories, Saint Kitts and Nevis face significant challenges with local agricultural production. High operating costs and competition from larger international markets continue to impact small farmers in the Caribbean. Saint Kitts has transitioned from a largely agrarian society that thrived on sugar cane production, to a tourism-dependent, service economy. Nevis has had a similar transition, but because it was not as

heavily “monocropped” for sugar cane production during the colonial period, the island has a long history of reliance on agricultural and fisheries production and this continues to influence local attitudes towards the sector today. There is evidence that livestock farmers on Nevis produce a greater quantity of animals than those on its sister isle of Saint Kitts.

From our assessment of economic activities in Saint Kitts and Nevis, the following uses and users of fish silage were considered:

Users

1. Livestock farmers

The Saint Kitts and Nevis Department of Agriculture keeps a repository of farmers that have registered their operations in either island. This register shows that there were 448 registered farmers in Saint Kitts in 2017 but the list does not detail the number of active farmers on each island. From the data it is difficult to determine the total number of farmers that may be potential users of silage products on both Saint Kitts and Nevis. Furthermore, stakeholder consultation meetings revealed that in Nevis, artisanal farming can be considered a common community practice. Many households keep a small number of livestock and many of these animals are not accounted for in the livestock production data for Nevis. As a result, when these “unaccounted for” livestock numbers are combined with the recorded local production quantities, the level of production in Nevis is possibly greater than that of Saint Kitts.

Secondary data on agriculture production at the national level is scarce. Table 14 shows the production of crop farming is much higher than that of livestock production.

TABLE 14
2018 Crop production data (’000 kg)

Commodities	January	February	March	April	May
Livestock	10.21	9.49	9.83	29.53	29.53
Crop	107	90	86	297.4	283
Total	**117.21**	**99.49**	**95.83**	**326.93**	**312.53**

Source: Department of Agriculture

Stakeholder consultations that were conducted during the scoping mission highlighted that there has been a significant decline in livestock production which could be attributed to:

- An increase in imported meat products, which have outpriced locally produced meat products.
- The high cost of feed continues to be a restriction to market penetration for local livestock producers.

As a result of these challenges, many farmers have either exited the agricultural sector or have had to reduce the quantity of livestock that they produce.

2. Aquaculture producers

Along with crop and livestock producers there is one major aquaculture producer in Saint Kitts and an aquaculture pilot test facility used by the Department of Agriculture in Nevis.

The feed for the Saint Kitts and Nevis Aquaculture Pilot Project and Environmental Research (SNAPPER) farm is imported from Miami, United States of America, and is a major contributor to total production costs. Also, it is widely known that local consumers in Saint Kitts and Nevis generally prefer marine fish and a lower price is the primary attraction of freshwater fish products. In consultations with the proprietor of SNAPPER farms and the Department of Agriculture in Nevis, it became apparent that energy costs and feed costs force market prices for cultured freshwater fish products to be significantly higher than marine fish products and imported freshwater fish products. As a result, aquaculture has not yet been developed as a

commercially viable agricultural product in Saint Kitts and Nevis and it is not considered as a major user group for fish silage. Until production on a commercial scale has been developed locally, aquaculture must be considered as a secondary user group.

In addition to the SNAPPER farm, there is a pilot project being developed in partnership with Ross University and a private investor to establish a commercial aquaculture farm that is anticipated to produce 4.5 million kg (10 million lbs) of Florida pompano in cages anchored six to eight miles off the west coast of Saint Kitts. If this project materializes, it will represent a significant opportunity for the utilization of fish silage.

Fish silage penetration potential for the agriculture market

Sector context

Livestock production is integral to the sustainable development mandate of CARICOM states and is being supported by the Government of Saint Kitts and Nevis despite the challenges faced.

In Saint Kitts and Nevis, livestock feed is supplied primarily by the Department of Agriculture at a subsidized rate of USD 35 to USD 40 per 22.67 kg (50 lb) bag. There is also a small number of private importers who supply feed at marginally higher rates. The cost of feed is the same for starter, grower and finisher feed rations, which all contain different protein contents. As a result, although protein content is a major contributor to the cost of feed, it is not represented at the point of sale for local farmers.

The Department of Agriculture is the largest supplier of feed. There is no feed input production or ration mixture production being executed on a large scale in Saint Kitts and Nevis. Animal feed is sourced from Saint Vincent and the Grenadines or Grenada and is sold and provided by the supplier, without any value-added production being carried out in Saint Kitts and Nevis. Feeds are stockpiled in the Department of Agriculture's facilities and purchased directly from the government departments by end users, with very few private feed retailers included in the process. This has created a monopoly and significant dependency on government to supply the feed that is required for livestock production in Saint Kitts and Nevis. The Department of Agriculture supplies approximately 900 bags/20 412 kg (45 000 lbs) of feed per month. A significant burden is placed on the Ministry of Agriculture when fuel, transport and source prices for the provision of feed increase. It is because of this challenge that the Department of Agriculture in Nevis has explored various procurement options in an effort to reduce the cost of livestock feeds. The Department uses different shipping procedures and sources to those used by the same department in Saint Kitts. However, feed products carry similar market prices and are used in the same way by end users.

Livestock feeds are purchased in small quantities on a weekly basis by farmers. In stakeholder consultations with local livestock producers in Saint Kitts and Nevis, it was identified that the level and type of production is different on the two islands. For example, representatives from the Department of Agriculture in Saint Kitts stated that the term "large pig producer" typically implies a farmer operating with 20 pigs, while in Nevis it is used for a farmer who has approximately 100 pigs or more. In general, the productivity of the livestock sector in Nevis was considered to be significantly greater than the livestock sector in Saint Kitts. Furthermore in Nevis, various value-added products have been developed for locally produced livestock.

This difference highlights the greater potential for the use of fish silage in Nevis compared to Saint Kitts. The value-added processing that is done in Nevis also introduces additional production possibilities for the fish silage industry. Because limited data was made available for a quantitative comparison of productivity between the islands, observational accounts were used to identify differences. It was evident from this observation that livestock production is greater in Nevis and consequently Nevis was used as a proxy for determining market potential.

Farmers in Nevis stated that they were interested in the potential value that fish silage could create, but it needed to meet three criteria before being considered by them. These are:

1. Cost: fish silage must enter the market at a significantly lower per unit price than existing feeds.
2. Convenience: fish silage must be provided as a convenient user option for farmers.
3. Content: fish silage must be properly managed and processed to ensure stable nutritional value standards.

Criteria 1

The cost of feed was considered to be a major barrier to productivity in the livestock production sector. Farmers have structured their operations to accommodate this unavoidable expense and will pay special attention to the cost of any feed inputs.

When presented with the opportunity to utilize feed inputs that can reduce the overall cost of feeds, livestock producers were immediately open to exploring these possibilities. This strong desire presents a great opportunity for the proposed silage industry to have a marked impact on local agriculture.

Criteria 2

It was found that farmers in Saint Kitts and Nevis do not store large quantities of feed. Typically 22.67 kg (50 lb) bags of pre-packaged ration mixture are purchased from the Department of Agriculture on a weekly basis. Also, most farmers in Saint Kitts and Nevis have only ever used these ration mixtures that are provided by the government and have limited experience of utilising additives and/or wet feeds. Consequently, the longstanding cultural practices of local farmers will be a significant consideration for the development of a productive silage industry.

Any change to the longstanding habits of feed use will require a strong education campaign that convinces users of the benefits of fish silage. Furthermore, local farmers stated that any new products should not create any major disruptions to their daily routines because any additional tasks would be restrictive to farmers that engage in additional livelihood activities. It was estimated that less than one hour of additional time per day could be afforded for new activities. Even with the hypothetical scenario of a 50 percent reduction in feed costs, farmers stated that time constraints may present a significant barrier. It is clear that a major contributor to a farmer's willingness to pay for any feed product is convenience and ease of use.

Criteria 3

Farmers in Nevis were concerned about the nutrient content that would be supplied through fish silage products. In order for them to have confidence in silage products, farmers stated that they needed to know what the fat to protein ratio is for every dose of fish silage used. Also, it was a shared belief that this ratio must be kept stable so that no further calculations must be made by the end-user.

Market penetration considerations

Farmers have highlighted the need for stable silage quality to be maintained. However, because fish landings fluctuate by species and quantity on a monthly basis, additional steps for determining the protein content ratio must be included in the silage production workflow. This may require large quantities of silage to be stockpiled and centrally processed before a stable mixture can be supplied to the end user. However, livestock feeds are currently supplied by a central provider, so building the capacity of the supplier to manage the protein to fat ratio may provide users with the stability that they require.

Fish waste suppliers

The amount of waste that can be generated varies depending on the species of fish, but fish waste can be supplied from the following main source:

- Primary landing sites
- Secondary landing sites
- Individual fishers.

Although fish waste is currently discarded at sea, stakeholders pointed out that once collection facilities were made available and a fair rate was ascribed to the fish waste, collection of waste would become an attractive income earner for fishers.

Perceived challenges

The culture of dealing with fish waste

Currently there is no monetary value placed on the fish that does not make it onto the plate. As a result, this waste is discarded by every user along the supply chain; the only secondary use of fish waste is as a deterrent for monkeys on farms.

The practice of discarding the viscera at sea has its origins in the knowledge that if the viscera are left in the fish, its quality is affected. At the fisheries complex, representatives stated that the fish must be gutted before it is brought into the complex. Because of this practice, fish waste that includes the viscera cannot easily be collected from the fisheries complex unless efforts to change this cultural practice are given priority. Also, any fish waste that remains after processing is discarded in the nearshore area close to the point of sale.

Fish waste supply

Due to the common practice of disposing fish entrails at sea, a significant portion of the fish waste does not currently make it to shore. This practice will limit the quantity of fish waste that is available for the production of silage, unless a specific effort is made to either change the practice or increase the amount of fish that is landed. Also, stakeholders noted that due to the large volumes of conch harvested, conch waste could be used in silage production. Conch is landed at two main sites and therefore its collection would be relatively easy. Conch waste does not contain bones and therefore is easier to grind compared to fish waste.

Furthermore, there is currently a peculiarity with supply and demand that may affect centralized silage production for both islands. In Saint Kitts, more fish are caught and processed at the fisheries landing sites than in Nevis. However, more livestock production currently occurs in Nevis, potentially increasing the demand for feed additives from fish silage. These differences in supply and demand require that different systems be explored for Saint Kitts and Nevis. These supply chain scenarios are discussed in Section 4.

Potential opportunities

Additional fisheries revenue potential for fishers

During key informant interviews with fisheries representatives in Nevis, participants stated that the idea of collecting the fish entrails would be easily accepted once a value was placed on these products. When asked about a possible rate for the fish waste that is usually discarded at sea, a local fisher stated that a price of ECD 2 per 0.45 kg (1 lb) would be an acceptable rate for the collection, storage and transport of this fish waste, if the waste is collected at a point close to the fisheries complex.

Potential benefits for livestock production

Livestock production in Saint Kitts and Nevis is affected by two major challenges: the cost of feed and competition from imported meat products.

Cost of feed

Feed in Saint Kitts and Nevis is sourced from Grenada and Saint Vincent and the Grenadines. Individual feed inputs are imported from an international supplier and ration mixtures are combined in the source countries (Grenada or Saint Vincent). These mixtures are shipped

directly from the source country and transported up the island chain until they reach Saint Kitts and Nevis, or they are transferred through an international transshipment hub in Miami, United State of America, to their final destination in Saint Kitts and Nevis. Both of these processes incur significant shipping costs that are transferred to the cost of feed in the country. The government of Saint Kitts and Nevis subsidizes the cost of feed in an effort to support the productivity of the livestock industry. However, despite these subsidies, the cost of feed remains restrictive and farmers have had to supplement the commercial feeds with other locally available products like malt and barley grains, molasses or restaurant food scraps. As a result of these challenges, farmers are open to any products that could reduce the cost of feed. Local farmers in Nevis explained that alternative products would be considered viable and competitive if they were able to reduce the price of feed by half to ECD17.50 per 0.45 kg (1 lb). This would mean that silage must enter the market at a maximum of ECD 0.35 per 0.45 kg (1 lb) to be competitive.

During the stakeholder consultations it was determined that the major variable that would affect their willingness to pay for fish silage is the convenience of supply, transport and use. However, the overall consensus is that, once made easily accessible and affordable, fish silage is an attractive option for lowering the cost of livestock feed in Saint Kitts and Nevis.

Imported meat products

Like many other Caribbean territories, imported meat products have presented significant challenges for livestock producers in Saint Kitts and Nevis. In 2016, meat imports for Saint Kitts and Nevis were valued at USD 9.9 million and grew at a rate of 8.15 percent after 1967 when they amounted to USD 445 000 (World Data Atlas, 2019). These imported products are heavily subsidized and livestock farmers are often outcompeted by retail companies that procure meat products from international suppliers. Due to this competition, the cost of meat produced in Saint Kitts and Nevis is not determined by the cost of production, but by the market rate for imported meats.

It is because of these challenges that local livestock farmers and the Director of Agriculture in Nevis showed considerable interest in utilizing the silage products for reducing the cost of feed. It was explained that cost and convenience were the main considerations for farmers in both Saint Kitts and Nevis.

Existing practice of waste separation

The fact that all fish waste is discarded in the nearshore close to the point of sale, or from fishing boats by fisherfolk, means that users already separate their fish waste from inorganic waste before discarding. Key informant interviews and site visits revealed that fish waste is not stockpiled in large quantities from weekly or daily activities but is kept in 19 litre (5 gallon) buckets next to individual processing stations and discarded in the ocean once the bucket is full. Because of the stench, fish waste is not combined with other municipal waste at the fisheries complexes, while all other waste is disposed of in skips that are collected weekly. Meanwhile, independent roadside processors generally discard fish waste in the ocean where they operate and have little inorganic waste to be considered. Since these activities already result in the separation of fish waste from any other types of waste, the focus can be placed on capturing this waste before it makes its way to the ocean and is not complicated by the need to develop a culture of fish waste separation.

4. Supply chain review

Fish waste suppliers
The quantity and quality of fish silage that can be supplied to farmers is solely dependent on the quantity, freshness and type of fish waste collected. The organizations and individuals that currently produce fish waste include:

Primary sources
- fisheries complexes and landing sites.

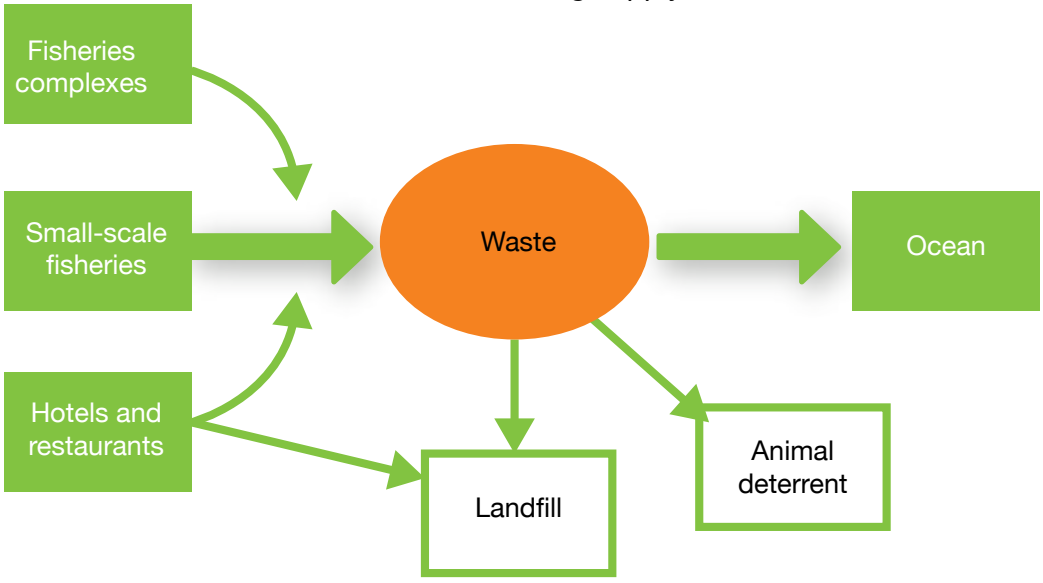
Secondary sources
- small-scale fishers
- hotels and restaurants.

4.1 Supply chain scenarios
In order to assess the infrastructural and supply chain needs of fish silage production and utilization in Saint Kitts and Nevis a number of possible supply chain scenarios have been developed based on the study results. The configurations are discussed next.

4.1.1 Scenario A
Scenario A (Figure 18) presents the current supply chain. Waste is generated from three main sources: (i) fishers at sea who gut the fish before landing it at the various fisheries complexes where further processing is done, (this generates more waste which is also discarded in the ocean); (ii) small-scale or artisanal fishing generates waste which is discarded in the nearshore area after processing takes place on the beach, and (iii) hotels and restaurants generate waste from imported, mainly processed fish. This waste is mixed in with municipal waste which is collected at the property and hauled to the landfill.

According to stakeholders interviewed, almost all of the fish waste generated is discarded at sea or in the nearshore if further processing is done onshore. It was noted that a small proportion of waste is collected by farmers who use it as a deterrent to monkeys on their farms. Stakeholders had very little knowledge on fish waste utilization streams and were keen to learn new ways to use the waste they generate.

Figure 18
Scenario A – existing supply chain



Advantages of Scenario A

One of the main advantages of the existing scenario, which holds for all others, is the availability of space at each of the fisheries complexes and at the Department of Agriculture in Nevis which is the largest land owner on the sister isle. Fish waste could therefore be stored and silage produced and sold from any of the publicly run facilities. In addition, all stakeholders in the public sector interviewed noted their keen willingness to participate in being trained in fish silage production.

In the current supply chain, fish offal is disposed of at sea and if it is to be used for post-harvest activities it is already sorted and would only need to be stored in such a way that ensures its continued separation from other forms of waste. Another advantage of the current supply chain is the numerous fishing and farming cooperatives in both Saint Kitts and Nevis. These cooperatives can act as facilitators to coordinate the collection of fish waste and the production of silage.

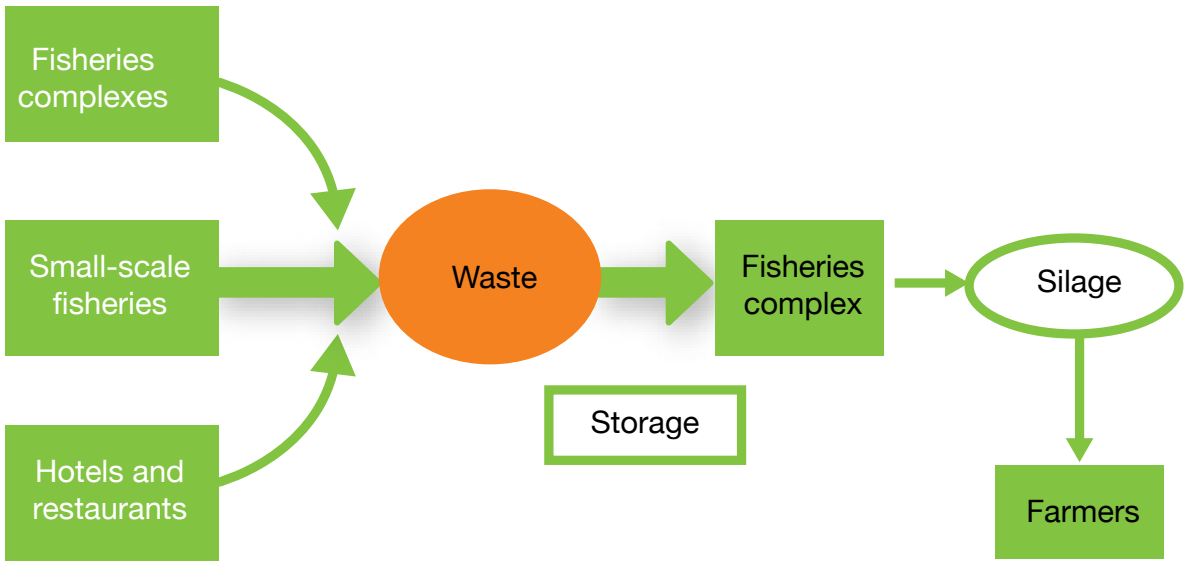
Limitations of Scenario A

The major limitation of Scenario A is that the majority of fish waste is discarded at sea. A new practice of storing the waste on board fishing vessels, to be collected at the complexes, will have to be introduced and inculcated. To overcome the practice of discarding fish waste at sea, education and training will be critical to the success of any post-harvest activities that create value-added products from fish waste.

4.1.2 Scenario B

Scenario B (Figure 19) proposes that fish waste is collected at an identified fisheries complex and stored there. The public complex purchases the fish viscera directly from the fishers and the waste is then converted to silage and stored on the premises. Silage is then sold to farmers directly. This scenario creates a central collection, storage and selling point in the supply chain, taking advantage of the existing facilities at the complexes. In this scenario it is assumed that fish waste is collected in Saint Kitts and silage is sold to farmers in both Saint Kitts and Nevis.

Figure 19
Scenario B



Advantages of Scenario B

Creating a central collection point at one of the fisheries complexes reduces the cost of storing the waste and silage. Also, the human resources currently working at these facilities can be trained to produce silage, which reduces the cost of production.

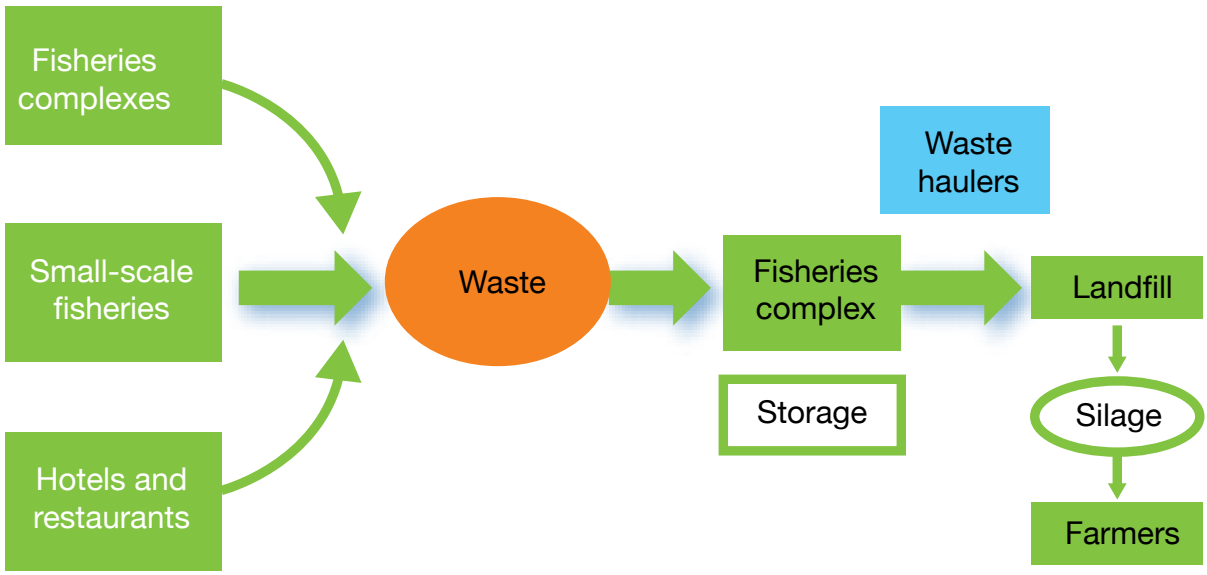
Limitations of Scenario B

The Scenario B supply chain is limited by its ability to provide silage to Nevis which has the higher production of livestock and possibly the higher demand for silage. If silage is produced in Saint Kitts and has to be transported to Nevis, this increases the cost and the risk that transportation poses to its quality.

4.1.3 Scenario C

This supply chain is outlined in Figure 20 and assumes that waste is collected at the fisheries complexes and transported to the landfill to be converted to silage. The Solid Waste Management Company (SWMC) stated there was ample space for silage to be produced, however its role in the process would be solely to lease available land. SWMC noted a private organization would have to conduct the silage production operations. SWMC has experience in this type of arrangement as compost was previously produced at the landfill but production was halted in 2017. In this scenario, silage is produced at the landfill and sold directly to farmers.

Figure 20
Scenario C



Advantages of Scenario C

The main advantage of this scenario is the potential for scalability of production at the landfill as SWMC has 6.2 hectares of available land. If a private entity is able to financially invest in the initial set up of a facility this could provide more than adequate capacity for production. The landfill also currently has a silo which can be used for fish silage production.

Limitations of Scenario C

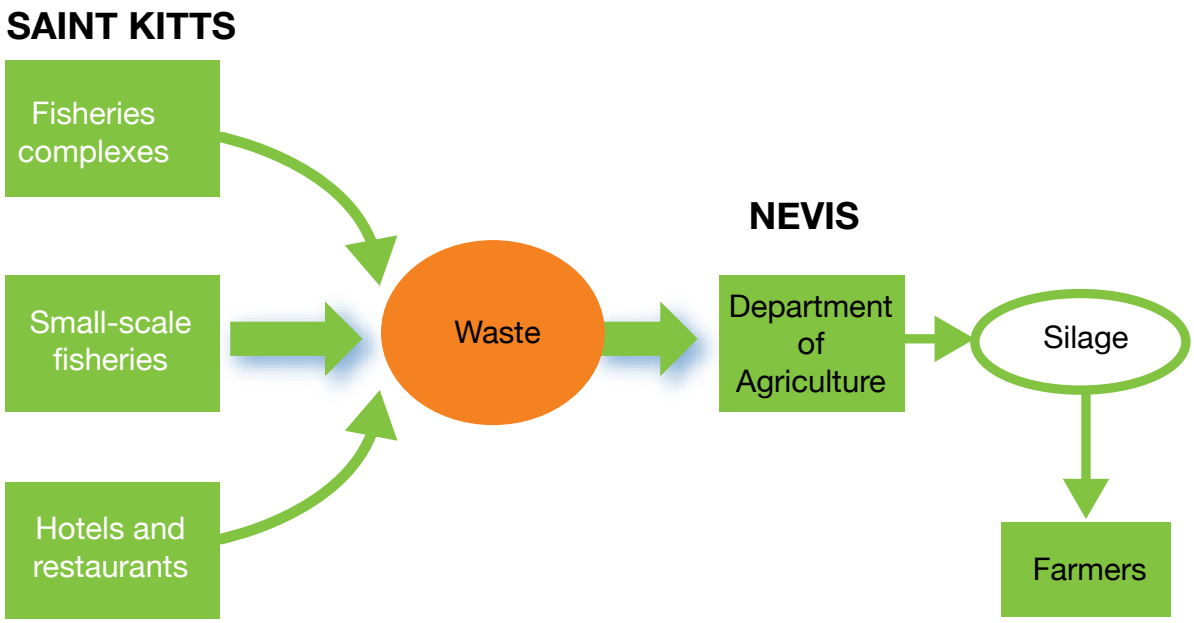
SWMC at present does not collect waste from the fisheries complexes. Therefore, the private entity responsible for silage production would have to pay for waste hauling services to ensure waste is transported from complexes to the landfill, increasing the cost of production. Also, SWMC has no capacity to collect, separate and store organic waste to due limited resources. A new sorting practice would have to be implemented, particularly at hotels and restaurants in order for fish waste to be separated from other organic and municipal waste.

4.1.4 Scenario D

Figure 21 depicts scenario D which attempts to exploit the major advantages in both Saint Kitts and Nevis in order to produce and utilize fish waste. This scenario assumes that fish waste

is collected at a fisheries complex and transported to the Department of Agriculture for the production and storage of silage. Collecting fish waste at a central point in Saint Kitts would ensure a large volume of waste would be collected. This waste is then transported to Nevis' Department of Agriculture to be converted to silage and sold to livestock farmers in Nevis, which produces more livestock and consequently would have a greater demand for silage.

Figure 21
Scenario D



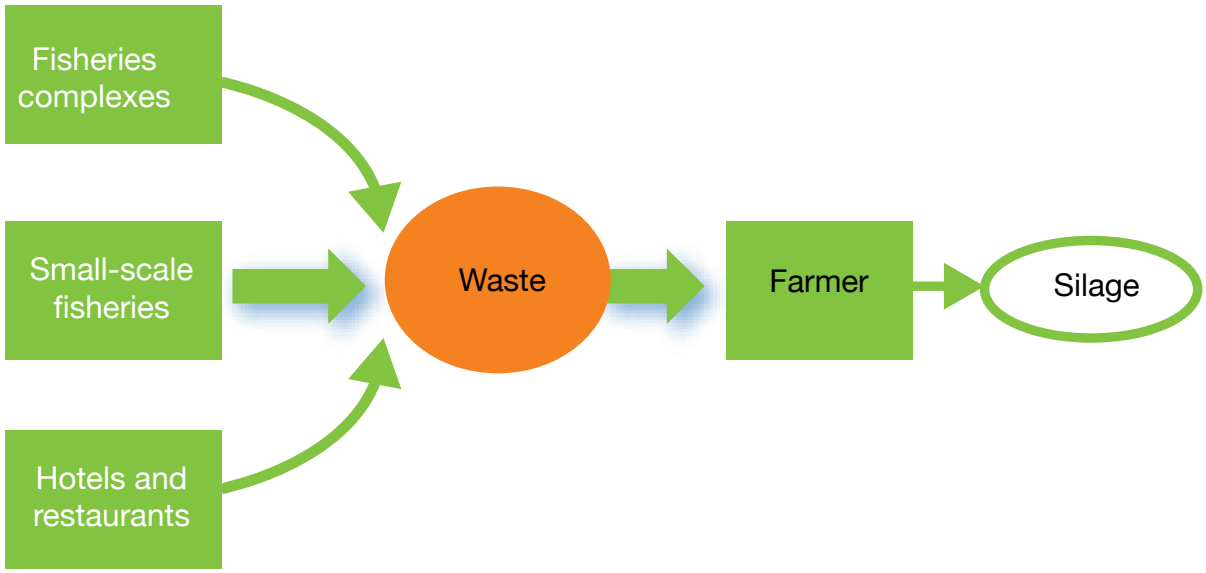
Advantages of Scenario D
Nevis has a thriving livestock industry, particularly pig rearing for pork meat. The sister isle has a meat processing plant which makes value-added meat products such as sausages and smoked meats. The presence of a meat processing plant provides an opportunity to further expand the value-added activities on Nevis, in relation to both fisheries and farming. Also, as the Department of Agriculture is the largest land owner in Nevis, there is great potential to produce silage and because of the many pig farmers on island, there is a market for silage. There are currently 11 large pig farms in Nevis which on average have 100 pigs each. Therefore, there is a willingness by farmers to try alternative feed ingredients if they can reduce the cost of production.

Limitations of Scenario D
Farmers in Nevis noted that convenience and cost are their major concern in relation to incorporating new farming techniques. Most farmers in Nevis are part-time farmers and if the use of silage is time consuming, it may not be feasible. Also, they stated that in order for silage to be cost-effective it would have to cost half the price of a feed bag, which is currently ECD 35. Also, transporting fish waste from Saint Kitts may pose challenges with respect to quality, cost and consistent supply.

4.1.5 Scenario E

Many farmers stated they were interested in utilising fish silage as a supplement to feed. Scenario E (Figure 22) places the farmers as the agent for collecting the fish waste from the complexes and producing silage on their farms. Since silage can be produced relatively easily on small farms, this supply chain assumes that farmers not only act as users, but also as producers.

Figure 22
Scenario E



Advantages of Scenario E
Placing the production of silage with the end user would allow for better waste quality management because farmers would control when and how they produce silage for their livestock. In doing so, silage is prepared based on the scheduling of the farmer's needs which should reduce wastage. Small-scale production of silage is also more cost-effective if silage can be used as a booster to supplement feed.

Limitations of Scenario E
Placing production with the end user, at the individual level, means there is limited scope for scalability and limited scope for taking advantage of economies of scale. Also, allowing individual farmers to produce silage would require an effective health and safety programme, whereby extension officers from either the DMR or Department of Agriculture, regularly check and monitor the production and storage of the silage on farms. This scenario also implies a greater level of training is required at the individual level.

5. Financial assessment

5.1 CAPEX and OPEX estimates

The financing requirement for the production of fish silage in the Saint Kitts and Nevis context is directly related to the type of supply chain configuration that is implemented. Regardless of the type of configuration selected, there are standard CAPEX and OPEX that will be required. The expenditures identified are aligned with those presented in Blanc and Le-Bars (2009) where fish silage equipment requirements were outlined, and Forbes and Sumner (1992) where the economic feasibility of fish silage production was investigated in Australia. For the purpose of this study, financing requirements are calculated based on two scenarios: (i) the production of silage is centralized at a publicly owned facility, and (ii) production of silage is decentralized and carried out by individual farmers.

CAPEX and OPEX items	Assumptions
CAPEX	
Land	There are many areas under public ownership where silage can be produced and it is assumed land will be free of charge.
Building	As with buildings and land, the DMR and Department of Agriculture Nevis own numerous areas and building space could be used free of charge.
Grinder (commercial)	A commercial grinder should suffice if the production occurs at a central location such as BFC. A commercial electric grinder ranges in price between USD 2 500 and USD 3 500.
Grinder (individual)	Small-scale meat grinders could be utilized if production occurs at the fish vendor and/or the farmer level. Meat grinders range in price from USD 20 to a maximum of USD 300.
Testing equipment	pH meters range in price from a minimum of USD 20 to a maximum of USD 250. A more cost-effective testing instrument is litmus paper which costs USD 3 to USD 25 for packages of 75 to 100.
Mixing tank	Mixing tanks come in various sizes and materials. Given that the amount of waste produced daily is approximately 35 kg, a mixing tank with the capacity of 37.85 litres (10 gallons) can be utilized. A stainless steel 37.85 litre (10 gallon) mixing tank is priced at approximately USD 1 000.
Storage tank	As with the mixing tank, the size of the storage tanks would be determined by the volume of waste collected and the silage produced. Here it is assumed that two to three storage tanks of an approximate 75.70 litre (20 gallon) capacity would be sufficient. These tanks are priced between USD 350 and USD 2 500.
OPEX	
Labour	It is anticipated that, if production is conducted within the fisheries complexes, at least one staff member will be needed to mix and monitor the waste. Supervisors at all the fisheries complexes noted their willingness to participate in the production of silage. At present, fish processors are paid approximately USD 135.00 (ECD 360.00) to USD 150.00 (ECD 400.00) per week.
Fish waste	Fish waste is estimated to cost ECD 2 per 0.45 kg (1 lb).
Waste services (skip & transportation)	If waste is collected and stored at a fisheries complex, and if silage is produced there, then this cost can be absorbed by DMR which already pays for skip services.

The CAPEX and OPEX for Scenario A, where production of silage is carried out at a publicly owned facility are based on the following assumptions:

1. Land and building assets are provided free of charge.
2. The public markets are the actors who are responsible for the production of fish silage.
3. The waste produced is 35 kg[10] per day.
4. The cost estimates are reflective of year one of operation and do not account for year on year expenditures, such as depreciation of assets.
5. Fish silage is sold directly to farmers.

[10] Based on method 2 estimate of fish waste generated.

TABLE 15
CAPEX and OPEX for publicly operated fish silage production

Expenditure	USD	Notes
Land	-	It is assumed that government provides land free of charge for the production of silage.
Building	-	It is assumed that waste collection and silage production is conducted at a fisheries complex.
Grinder (commercial)	3 500.00	A commercial grinder would be required under this scenario.
Mixing tank	1 000.00	The cost of a 37.85 litre (10 gallon) stainless steel mixing tank.
Storage tank (2)	5 000.00	The storage tank cost is estimated as the average of cost of two 75.70 litre (20 gallon) stainless steel tanks.
Testing equipment	250.00	It is assumed one electronic ph tester is needed.
Total CAPEX	**9 750.00**	
Labour	15 600.00	The cost of labour is calculated based on two staff members (at USD 150 per week) responsible for waste collection and silage production.
Fish waste	9 645.00	The cost of waste is estimated at ECD 2/USD 0.75 per 0.45 kg (1 lb).
Waste services		
Total OPEX	**25 245.00**	
Total cost	**34 995.00**	

The total CAPEX and OPEX for silage production undertaken by a public facility is approximately USD 34 995 in the first year of operation. Labour costs account for 44 percent of the total cost which is an expenditure that could either be absorbed fully or partially by staff members of the fisheries complex, or the fishers themselves. CAPEX costs account for 27 percent of total cost, taking full advantage of existing infrastructure that can be utilized for storage and production activities.

The CAPEX and OPEX for Scenario B, where production of silage is carried out on individual farms, are based on the following assumptions:

1. Land and building costs are absorbed by existing farming capacity.
2. Farmers are responsible for production themselves, or hire another person to assist in silage production.
3. The quantity of fish waste required by a farmer to supplement 25 percent of current feed consumption is 400 kg per month.
4. The cost estimates are reflective of year one of operation and do not account for year on year expenditure, such as depreciation of assets.
5. Fish silage is produced with the purpose of cost savings to increase farm profitability rather than production for revenue generation.

TABLE 16
CAPEX and OPEX for small-scale fish silage production

Expenditure	USD	Notes
Land	-	
Building	-	
Grinder (individual)	300.00	A small-scale grinder would be required under this scenario.
Mixing tank	-	Farmers could reuse 19 litre (5 gallon) buckets which can be found on farms.
Testing equipment	100.00	At the individual level, litmus paper could be used to test pH levels.
Total CAPEX	**400.00**	
Labour	7 800.00	It is expected that famers would produce the silage themselves, but they may need an additional worker to assist with production.
Fish waste	3 600.00	It is assumed that fish waste replaces a quarter of the feed farmers need for their pigs. Pig farmers use approximately 1 650 kg of feed monthly. This would mean they need approximately 400 kg of silage per month.
Waste services	-	
Total OPEX	**11 400.00**	
Total cost	**11 800.00**	

Total estimated CAPEX and OPEX for silage production at the individual level is USD 11 800 for year one. The main cost of production is labour which could be absorbed by persons who already work on farms. In this scenario there is very little CAPEX; it accounts for only 3 percent of the total cost.

One limitation to the estimation of OPEX in both scenarios is the exclusion of one of the the main components of silage production – acid – and other inputs such as salt, sugar and other vegetable matter.

TABLE 17
Cost of production for 100 kg of fish silage

Cost of silage production						For 100 kg or 10 kg/day	
Cost		**Items**	**Units**		**ECD**	**Biological**	
Operational		Fish waste	ECD/ 100 kg		ECD 220.00	ECD 220.00	ECD 220.00
		Waste transport	ECD/ 100 kg		ECD 100.00	ECD 100.00	ECD 100.00
	Electric cost	Meat grinder	hr/ 100 kg	ECD/ KWH	ECD 0.75/kw	ECD 38.50	ECD 38.50
	Biological agent	Molasses/ yogurt	kg/ 100 kg	ECD/Kg		ECD 115.00	ECD 115.00
	Employees	Production	ECD/ 100 kg			ECD 180.00	ECD 600.00
	Cleaning	Detergent & other cleaners			ECD 60.00	ECD 60.00	ECD 60.00
Fixed	Electric energy	Whole space	Hr/ 100 kg	ECD/ KWH	ECD 1.58	ECD 1.58	ECD 1.58
	Water		ECD/ 100 kg	ECD/ month	ECD 10.00	ECD 10.00	ECD 10.00
Total cost			ECD/ 100 kg			**ECD 725.08**	**ECD 1 145.08**
						USD 268.55	**USD 424.10**

Key informants were asked to validate the cost of producing 100 kg of silage in a month. Using the biological method, it is estimated that production costs are ECD 725.08/USD 268.55 per month (excluding labour) and ECD 1 145.08/USD 424.10 per month (including labour) (Table 17). These costs were perceived to be restrictive to the production of silage.

5.2 Revenue estimates

Fish waste in the context of Saint Kitts and Nevis could be converted to silage for the purposes of utilising waste that is discarded and to provide cost savings to farmers. Given there are no feed producers on the island, all feed is imported. Therefore, silage can be used to supplement existing feed products rather than be a primarily revenue generating product. Revenue estimates are assumed if the fisheries complexes sold the silage directly to farmers. Fishers stated they were willing to sell their waste for ECD 2.00/USD 0.75 per 0.45 kg (1 lb). At ECD 2.00/USD 0.75 per 0.45kg (1 lb) or ECD 4.00 for 1 kg, revenue from silage production is estimated at USD 46 296[11] per year. However, this price is uncompetitive when compared with current feed prices because feed is subsidized and sold at ECD 35 per 22.68 kg or ECD 0.65 for 1 kg.

TABLE 18
Revenue comparison

Item	Price per kg (ECD)
Complete feed	0.65
Fish silage	4.00

[11] Silage sold at ECD 4 per 1 kg at a production level of 11 574 kg annually.

6. Organizational assessment

The governance structure for the sovereign state of Saint Kitts and Nevis is unique – Saint Kitts is governed by the federal government and the Nevis Island Assembly (NIA) functions as the local government in Nevis. Although the NIA falls within the federal government, it is an autonomous entity and has sole responsibility for providing various types of services on the island of Nevis. The services of the NIA that are directly related to the production and utilization of fish silage include (i) agriculture, forests and fisheries, and (ii) refuse collection and disposal (CLFG, 2018). In view of the governance arrangements, this organizational assessment will jointly consider the regulatory framework to support the proposed configurations (see Section 4) in Saint Kitts and Nevis since both are governed by overarching legislation, and separately evaluate the preparedness of key actors in each island. This assessment will focus on three key sectors that are associated with the fish silage industry: fisheries, agriculture and waste management.

6.1 Regulatory framework: Saint Kitts and Nevis

The supreme legislative instrument for Saint Kitts and Nevis is the Saint Christopher and Nevis Constitution Order (1983). All other legal instruments must be consistent with the Constitution Order. In 2006, the Government of Saint Kitts and Nevis adopted a National Adaptation Strategy (NAS) 2006 to 2017. The NAS promoted the agenda of sustainable development and encouraged the fostering of appropriate legal and regulatory frameworks. Other initiatives that support the development of agriculture, the promotion of entrepreneurship, and the enhancement of training programmes for economic benefit are the National Environmental Management Strategy, the United Nations Convention to Combat Desertification National Action Plan, the Agricultural Strategic Plan (2005–2009), and the National Poverty Reduction Strategy (2011– 2015).

In the fisheries sector, the Fisheries, Aquaculture, and Marine Resources (FAMR) Act (2016) replaced the Fisheries Act of 1984. The FAMR Act made provision for the conservation, management, development, and sustainable use of the fisheries, aquaculture and marine resources of Saint Kitts and Nevis. The FAMR Act established a fund for fisheries, aquaculture and marine resources management and development, and provided for a FMP. Although the terms “fish waste”, “fish offal”, or “fish silage” are not explicitly mentioned in the FAMR Act, the instrument speaks to the regulation of post-harvest activities. Relevant persons and entities are mandated to keep records of harvesting, processing, transportation, storage, distribution and disposal of fish or fish products. The FAMR Act also encourages fishing and related activities to minimize waste and discards, and discourages pollution originating from fishing vessels. Other, related instruments, such as the Fisheries Regulations (1995) and National Environmental Action Plan (1994), do not reference fish waste or fish silage, and the Marine Pollution Act (2002) excludes fresh fish and parts thereof from “garbage” which allows fish offal to be discarded from vessels or platforms in the territorial waters of Saint Kitts and Nevis.

In the agriculture sector, the Constitution Order grants the right to carry out works that support the conservation of natural resources and agricultural development or improvement. In keeping with the Constitution Order, the Ministry of Agriculture developed an Agriculture Development Strategy (ADS) in 2006 and implemented the five-year programme from 2007 to 2011. The ADS was revised to the Agriculture Development Strategy (2013–2016) which provided guidance for actions to improve the production and marketing of crop and animal food and non-food products in Saint Kitts over the identified period. The Constitution Order also permits the Nevis Island Legislature exclusive power to make laws with respect to agriculture. International organizations such as the Inter-American Institute for Cooperation on Agriculture (IICA) and FAO have contributed by preparing a strategic plan with the aim of developing a programme that highlights and prioritizes needs in the agriculture sector (IICA, 2014), and by developing a country programming framework for Saint Kitts and Nevis in agriculture and other priority areas (FAO, 2015), respectively.

In the waste management sector, the Solid Waste Management Act (1996) provides the legislative framework for the promotion of best environmental practices relating to the storage, treatment and disposal of solid waste. This Act was amended to the Solid Waste Management

Act (2009) which grants the establishment of procedures to be implemented for the reduction, recycling, recovery, reclamation and re-use of waste and other substances. Neither fish waste nor fish offal were defined under the various types of waste listed in the Act, but the Act speaks to the handling, separation and processing of waste, and prohibits the disposal of other types of waste where alternatives such as recycling and composting are feasible.

6.2 Human and institutional capacity: Saint Kitts

Fisheries is one of the sectors within the DMR that falls under the purview of the Ministry of Agriculture, Human Settlement, Cooperatives and Environment. Key actors in the fisheries sector are the minister, director, deputy directors, the Fisheries, Aquaculture and Marine Resources Advisory Council, Licensing Committee, Appeals Committee, fishers and the fisherfolk community. The Advisory Council allows for representatives from several ministries with responsibility for sustainable development, environment, fisheries monitoring and control, planning, and finance. Other members of the council are representatives from the Saint Kitts and Nevis National Trust and the fisherfolk community. The DMR adopted the reformed method of an ecosystem-based management approach in fisheries, with the aim of conserving, managing, developing, and sustainably using marine resources.

The Department of Agriculture also falls under the purview of the Ministry of Agriculture, Human Settlement, Cooperatives and Environment. Key actors in the agriculture sector are the Agricultural Resource Management Unit, farmers, agro-processors, NGOs, and cooperatives. Under the ADS (2013–2016) the Ministry of Agriculture established the following programmes: Operation Food Security, Farming and Agricultural System Transformation, and AgriBusiness and Market Development. Findings from a study by IICA (2014) revealed the willingness and interest of stakeholders, particularly farmers and the staff of the Department of Agriculture, to see better management of agricultural chains and an increase in agro-entrepreneurial capacities. Thus, there was successful implementation of the ADS (2013–2016) owing to the collaboration of partners and stakeholders within the sector. The establishment of a demonstration farm allowed for the facilitation of training in agricultural science, farming technologies, and farm management (IICA, 2014). Such initiatives resulted in youth engagement in agriculture and entrepreneurship, dialogues to support the creation of policy, and beneficial exposure of locals to equipment demonstrations and training with the Caribbean Agricultural Research and Development Institute (IICA, 2016).

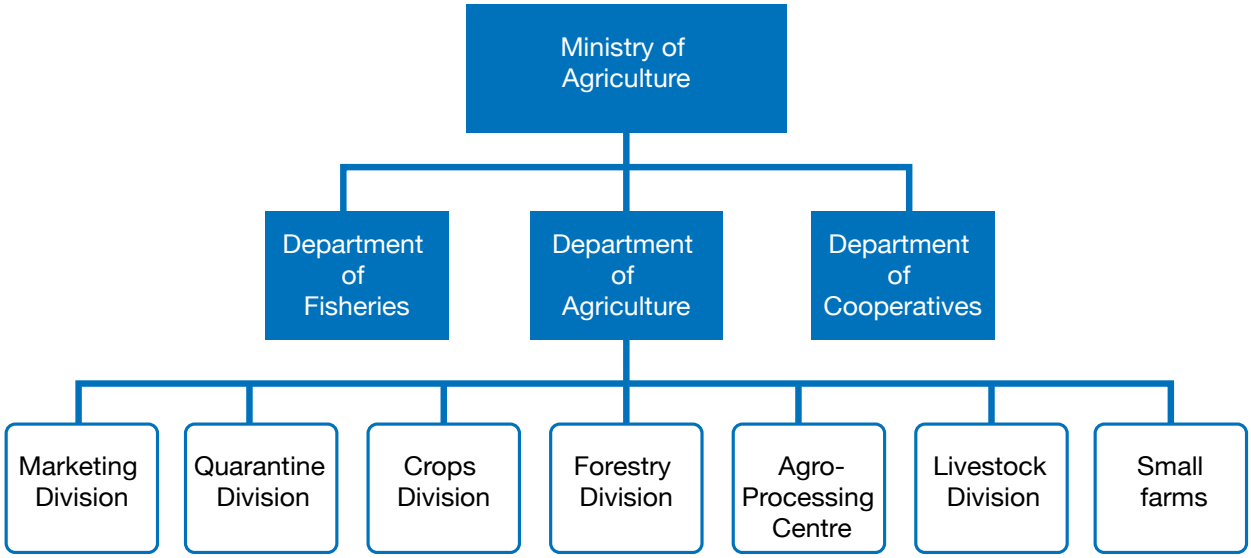
The Solid Waste Management Act made provisions for the establishment of the SWMC as a statutory authority. Under the Ministry of Health, the SWMC is the primary entity responsible for collecting and transporting waste throughout Saint Kitts, although there are private companies that provide similar services. Guided by the amended Solid Waste Management Act (2009) and governed by a Board of Directors (having no representatives from fisheries or agriculture), the SWMC collects, transports, separates, processes, treats, recycles and disposes of waste. The SWMC accepts various types of waste, including special waste. Fish waste and fish offal are not definitively grouped under “special waste”, even though this category includes ship-generated waste (i.e. garbage and waste oil) from cruise ships and other vessels. Given that the SWMC provides collection and storage facilities at harbours and anchorages to receive ship-generated waste, it is feasible to expect it will collect fish waste from those sites.

6.3 Human and institutional capacity: Nevis

In the Nevis Island Government, the ministries that are related to the production and utilization of fish silage are the Ministry of Agriculture, Lands, Housing, Cooperatives and Fisheries, and the Ministry of Health. The mission of the Ministry of Agriculture, Lands, Housing, Cooperatives and Fisheries is to transform and support the progressive growth of agriculture, fisheries and cooperatives to overcome the challenges of food security and poverty. A key part of the mandate of the Fisheries Department is to assess and regulate the fisheries resources of Nevis and to promote sustainable use of those resources. Duties of the six-member staff of the Department include training fishers, encouraging the establishment of fisherfolk organizations, and encouraging the wise use and conservation of fishery resources.

Figure 23 shows the organizational chart of the various departments and divisions for which the Minister of Agriculture is responsible. As observed, there are several portfolios under the Ministry which can reduce the availability of human resources and place excess strain on institutional capacity. However, having one umbrella ministry which mostly consists of entities needed for the implementation of fish silage production and utilization (i.e. fisheries, agriculture, cooperatives, markets division, livestock and small farms) should ease the facilitation and cooperation of all major actors.

Figure 23
Organizational chart for the Ministry of Agriculture in Nevis



The Nevis Solid Waste Management Authority – a statutory body of the NIA – is under the purview of the Ministry of Health. The mission of the Nevis Solid Waste Management Authority is to employ modern equipment and dedicated personnel in an effort to preserve and enhance the environment through proper waste management practices. The services provided by the Nevis Solid Waste Management Authority consists of bin rentals, collection of household waste and other bulky items, and community clean-up support.

6.4 Challenges and considerations

The organizational assessment showed a surge in policy instruments and strategies across the relevant sectors, especially agriculture, over the past decade. This finding confirmed that challenges that were previously identified, such as outdated legislation and inadequate platforms, are being addressed in Saint Kitts and Nevis. Nonetheless, there is a need for stronger inter-sectoral links to support an integrated approach to natural resources management. Additionally, the adoption of innovative approaches is still lacking – there are no instances or mentions of incorporating methods of silage creation or composting from fish offal, despite the challenge presented by the high cost of agricultural feed, limited use of technology, and an ageing farming population. Even with the strong linkages and support provided by regional and international organizations such as IICA, FAO and CARDI, there is still a strain on the human and technical resources which would challenge the effective implementation of a new industry such as fish silage.

7. Barriers and recommendations

7.1 Barriers

The barriers to silage production and utilization in Saint Kitts and Nevis are outlined below:

- Given the cultural practices and norms regarding fish waste and farming, the behavioural changes that would have to be made by fishers, to ensure a consistent supply of waste, and farmers to take up alternative feed options, could be prohibiting factors to silage production and usage.
- Lack of accurate fish catch weight data that includes fish offal is a major limitation because it limits the ability to calculate the total waste generated by fisheries.
- The declining production of livestock farming in Saint Kitts due to high production costs and competing imports, reduce the market potential for silage utilization by livestock farmers.
- The relatively higher potential price of silage restricts the competitiveness of silage in relation to existing complete feed.
- Although instruments such as the FAMR Act speak to the regulation of post-harvesting activities, none of the existing policies and sectoral strategies explicitly mention fish waste, fish offal or fish silage.
- The FAMR Act does not prohibit the discarding of fish or parts thereof in the waters of Saint Kitts and Nevis and therefore the current practice is within the legal parameters and any attempt to change the practice may be met with resistance.

7.2 Recommendations

The following recommendations should be taken into consideration if silage production and utilization were to be explored and/or undertaken in Saint Kitts and Nevis:

- The collection of fish catch data should include a better understanding of the total volume of fish caught by the sector.
- Policies and sectoral strategies should explicitly mention fish waste and fish silage, in addition to defining the roles and responsibilities of the various actors for the prospective fish silage industry.
- Inter-sectoral forums that include the sectors of fisheries, agriculture and waste management should be encouraged to determine if the production of fish silage should be jointly facilitated by stakeholders in Saint Kitts and Nevis.
- A robust educational campaign and training activities will need to be undertaken to change the longstanding habits of fish waste disposal at sea by fishers, and the feed use practices of farmers to convince them of the benefits of silage.
- The demonstration farm established by the Ministry of Agriculture in Nevis can be used to train and educate stakeholders about fish silage production.

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9. Appendices

Appendix 1: Revenue and expenditure

Annual operating surplus (soymeal price and molasses)

Sales revenue		**USD 528,485.76**
Units (t)	1 368	
Price	USD 386.32	
Total cost		**USD 386,593.84**
OPEX	USD 82.25	USD 112 518.00
Molasses (gallons)	USD 1.00	USD 120 682.00
CAPEX	USD 112.13	USD 153 393.84
Annual operating surplus		USD 141 891.92

Annual operating surplus (fishmeal price and molasses

Sales revenue		**USD 2 044 900.08**
Units (t)	1 368	
Price	USD 1 494.81	
Total cost		**USD 386 593.84**
OPEX	USD 82.25	USD 112 518.00
Molasses (gallons)	USD 1.00	USD 120 682.00
CAPEX	USD 112.13	USD 153 393.84
Annual operating surplus		**USD 1 658 306.24**

Appendix 2: Survey instrument

Feasibility Study for Fish Silage Production and Use in Three Caribbean Countries

Date: _____

Time: _____

Interviewee: _____

Location _____

Good morning/afternoon (insert name).

Thank you for agreeing to take part in this study which seeks to explore the feasibility of fish silage production and use in Barbados/Saint Lucia/Saint Kitts.

All information provided will be confidential and will not be linked to you in anyway. During the rest of the session, I'll be working from a script to ensure that all of my questions to everyone who participates in this study are the same.

The study will require you to answer a few questions about the potential for fish silage production and use in Barbados/Saint Lucia/Saint Kitts. The whole session is expected to take no more than 30 minutes.

I am going to record this session so that I have an accurate record of what was discussed, is that ok?

Do you have any questions before we begin?

Ref.	Question	Stakeholder
1.	Can you please state your name and give an overview of your role within your company/organization/industry?	All
2.	What are your thoughts on the potential of using fish waste to create value-added products?	All
3.	In your opinion, what amount of fish waste is being produced at fish markets/fish processing plants in the island on a monthly basis?	Fisheries Division & Fish Vendors
4.	Do you know of past projects/initiatives where fish waste was used to make value-added products? If yes, can you provide more information on these projects/initiatives?	Fisheries Division
5.	What barriers exist that would hinder fish silage production and use in Barbados/Saint Lucia/Saint Kitts? E.g. skills training, storage, transportation, technology	All
6.	What enablers exist that would promote fish silage production and use in Barbados/Saint Lucia/Saint Kitts? If none exist, what would be required to create an enabling environment?	All
7.	What are the conditions necessary for meeting the domestic market demand for fish silage?	All
8.	What commodities do you currently produce that fish silage be utilized in?	Food Processors, Farmers
9.	What quantities of fish silage would be required to be used in the production of the commodities mentioned above?	Food Processors, Farmers
10.	What price would your company be willing to pay for fish silage?	Food Processors, Farmers
11.	What would be required to sustain fish silage production?	Fisheries Division & Fish Vendors
12.	Can you identify the main actors that need to be involved to sustain production?	All

13.	What is the most appropriate arrangement to foster productive partnerships among these main actors?	All
14.	Do you perceive any risk factors associated with the production and use of fish silage?	All
15.	Do you have any recommendations for creating a viable enterprise?	All

This brings us to the end of this interview. Are there any other issues that you want to raise before we close off? We will share the results of this study with you in the near future as a token of our appreciation for your participation.

If you have any further questions related to this research, please feel free to contact:

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Sen. Crystal Drakes crystal.drakes@bluegreeninitiative.org
Mr. Jehroum Wood jehroum.wood@bluegreeninitiative.org

Appendix 3: List of interviewed participants

Organization	Stakeholder type	Name	Position
Pinnacle Feeds	Food processor and distributor	Adrian Yard	Senior Manager – Farm Service, Logistics and Retail
Ocean Fisheries Ltd	Fish processor and distributor	Frank Jordan	Managing Director
	Fish processor and distributor	Ezra Maynard	
Fisheries Division	Government	Joyce Leslie	Deputy Chief Fisheries Officer
Shorelinez	Fish processor and distributor	David Sumpter	
Ministry of Maritime Affairs and Blue Economy	Government	Michelle Wiggins	Quality Officer
BARNUFO	Civil society	Vernell Nicholls	President
BRMP	Sectoral association	Wayne Smith	President
Chickmont	Technical partner with Roberts Manufacturing	Carolyn Collymore	Productions and Operations Manager
		Geoffrey Goddard	Retiree
Morgan Fish House	Fish processor	Kyle Harris	Managing Director
Sundale Food	Fish distributor	Reggie Corbin	Company Director
Lashley Fish Processors	Fish processor and distributor	Dale Lashley	
Hijab and Skip Services	Waste hauler	Anderson Griffith	
Anthony Turton	Pig farmer		Owner

Appendix 4: BGI's mission schedule for Saint Kitts and Nevis

	Monday	Tuesday	Wednesday	Thursday
9:30 am	Meeting with Wilmoth Alleyne, Enforcement Officer/Acting Director of Department of Marine Resources	Meeting with Randy Elliot Director of Agriculture Department and Lemuel Pemberton Deputy Director Department of Marine Resources (Nevis)	Meeting at Basseterre Fisheries complex to interview fish processors	Meeting with Mr Brown, Owner of SNAPPER Farm
10:00 am				
10:30 am	Meeting with Director of Agriculture Department and Livestock farmers	Meeting with livestock farmers and fisherfolks (Nevis)		
11:00 am			Meeting at Old Road Fisheries complex to interview fish processors	Meeting with Wilmoth Alleyne, Enforcement Officer/Acting Director of Department of Marine Resources
12:00 pm	Lunch	Lunch	Lunch	
	Meeting with Pig Farmer			
1:00 pm	Meeting with Dr Leighton Marine, Potential Animal Feed Producer/ Farmer	Visit to Nevis Fisheries complex to interview fish processors	Meeting with Director Solid Waste corporation	

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