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Assessment of the Aquaculture Value Chain Incorporating Sensitivity to Climate Change

Ministry of Agriculture and Fisheries

DELIVERABLE 5:
FINAL REPORT

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1. EXECUTIVE SUMMARY

This report discusses the outputs of a climate sensitive network value chain assessment undertaken for the tilapia and ornamental fish industries of Jamaica. Given the significant threat posed by climate change to aquaculture production globally, this assessment departs from the premise that it is critical to understand how different components of a value chain are susceptible to climate phenomena: The more adapted is a value chain to potential climate change threats, the more capable it will be to retain and enhance its competitive advantage.

In addition to the formulation and validation of a climate sensitive value chain approach, this assignment also examined existing plans and programmes implemented by the National Fisheries Authority, in order to assess whether they can adequately support climate change adaptation in the two value chains examined.

Overall, this study finds that there are differentiated risks and opportunities generated by climate change along the tiers of the two value chains. Analysis of observed meteorological records show a warming and drying trend across the Region, as well as an increase in the frequency of high intensity hurricanes (Category 4 and 5), making imperative the development of best climate-smart practices for the sector. Input suppliers and producers are more susceptible to droughts, floods and changes in temperature, given the impact of these climate hazards on productivity and access to farms (during floods). Conversely, processors, vendors, retailers and exporters show a higher sensitivity to storms and hurricanes, given the potential impact of extreme weather events on infrastructure and processing/storage equipment.

The assessment of NFA documents shows that current plans and strategies in the aquaculture sector help to respond to climate change adaptation challenges and opportunities along both value chains, and generate a more enabling environment for private sector adaptation. However, there is a clear need for the consolidation and expansion of business-to-business and public-private partnerships to satisfy the adaptation needs of both value chains.

Under this context, the Aquaculture Division has an important role to play in the facilitation of stakeholder's dialogues and cluster development that would help to realise the adaptation opportunities for the sector. Key outcomes from this assessment, discussed in Sections 6 and Section 7 of this report, are also available in Excel format as Annex 2.

Stemming from this assessment, key recommendations for the Aquaculture Division are as follows:

- To mainstream climate change considerations into aquaculture management plans, ensuring that aquaculture operations follow best international climate-smart practice;
- To facilitate access to finance for the acquisition of climate smart infrastructure and equipment (e.g. solar water pumps, solar cooling systems and on-site water storage facilities);
- To liaise with the Climate Change Division and PIOJ in order to identify sources of climate finance and to develop additional services for the sector (e.g. early warning systems and climate insurance);
- To strengthen training and capacity building strategies that promote best practices and to improve extension services through the establishment of partner agreements and MOUs between the Aquaculture Division and other local entities;
- To strengthen partnerships and collaboration, particularly around the development of R&D services and products that could enhance the resilience of the two value chains (such as the development of alternative local feeds) and for promoting the dissemination of best practices;
- To provide continuity to this assignment, by:
    - Ensuring the findings and recommendations presented in this report are integrated into the new development plan for aquaculture; and
    - Facilitating the development of geographical clusters and/or thematic working groups to consolidate the relationship between actors that have been engaged through this assignment.

2. INTRODUCTION

Due to their dependence on natural resources, productive sectors such as aquaculture are strongly sensitive to climate phenomena. Climate change can affect aquatic systems and generate damages and losses in the aquaculture sector throughout their whole value chains. As greenhouse gas emissions remain unabated and the impacts of climate hazards on socio-ecological systems become more prominent, we see an increasing need for developing suitable adaptation and climate compatible development strategies for the sector.

Adaptive value chains are those where participating actors are able to harness strategies to continue delivering value, and hence retain their competitive advantage, in the face of physical climate risks. Value chains that are able to identify and quantify the impacts and flow on effects of climate change in their production systems, and that can implement soft and hard adaptation measures, are more likely to keep their competitive advantage in the long run and will be better prepared to respond to extreme climate events such as hurricanes and prolonged droughts.

The specific objective of the assignment is to assess two aquaculture value chains in Jamaica (namely tilapia and ornamental fish), using a climate sensitive network approach. In addition to the formulation and validation of a climate sensitive value chain approach, this assignment also examined existing plans and programmes currently being implemented by the National Fisheries Authority in order to assess whether they can adequately support climate change adaptation in the two value chains examined. The outputs from the assessment have been discussed and validated with key stakeholders in the tilapia and ornamental fish value chains, through their engagement in workshops and bilateral calls, to ensure the legitimacy and saliency of the assessment results. It is expected that results from this assessment will inform the future development of a value chain strategy for the tilapia and ornamental fish sub-sectors.

3. METHODOLOGY

The methodology applied in this assessment draws on the theoretical and methodological framework developed by the consultant, Dr Laura Canevari, as part of her doctoral thesis. It is discussed in the academic literature in Canevari-Luzardo (2019a,b) and Canevari-Luzardo, Berkhout and Pelling (2019). Key steps and components for this assignment are summarised in Figure 1 below.

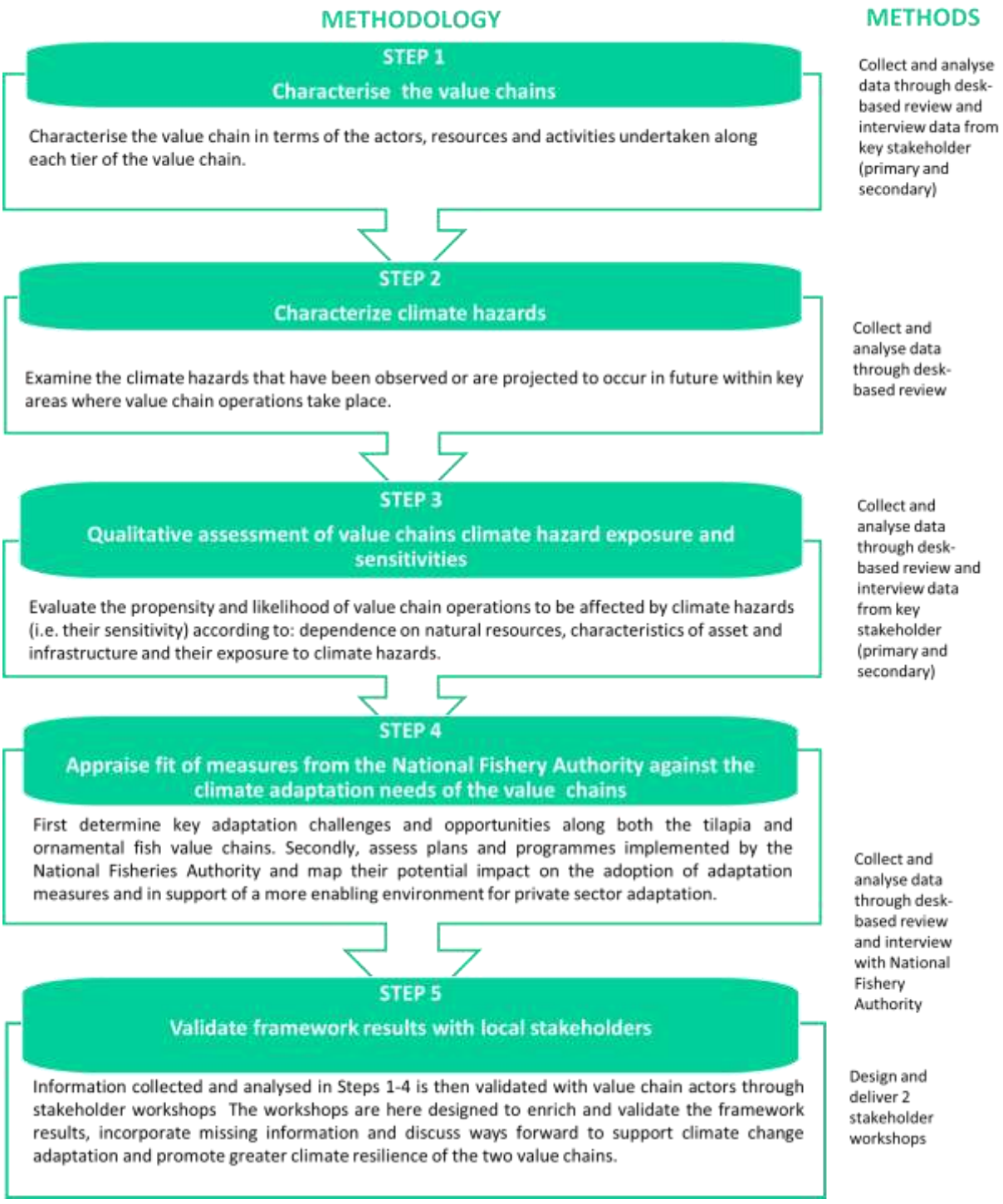

Figure 1 Summary of key methodological steps for this assignment

The framework provides a mechanism to:

- Characterises the value chain, in terms of its critical components: actors, resources and activities (STEP 1 in Figure 1)
- Examine climate hazard affecting the locations where value chain operations take place (STEP 2 in Figure 1)
- Define climate sensitivities along each value chain tier, accounting for the different characteristics and needs of different types of assets, resources and activities along the value chain and the proneness to damage of value chain operations to climate phenomena; and identify key adaptation barriers and opportunities along each value chain (STEP 3)
- Define the level of alignment of current aquaculture plans and programs with the adaptation needs of the value chains and determine if they fully address direct, indirect and transboundary climate risks (STEP 4)
- Validate framework and results with relevant stakeholders (STEP 5)

In addition, the framework here proposed examined the relationship between different components of the value chain and examined how material, information and financial resource flows along the value chain, drawing on Dr Canevari's PhD research results. This approach helped to identify key value chain actors and resource bottlenecks, drawing on network maps of resource flows produced by the consultant and can help guide the allocation of resources for the development of strategic partnerships for the sector.

3.1 STEP 1: Characterization of the tilapia and ornamental value chains

A value chain can be defined as a network of connected and interdependent **actors, activities** and **resources** that together form a structure through which to generate new value (Canevari-Luzardo 2019). Based on this definition of a value chain, an initial characterization of the tilapia and ornamental fish value chains was undertaken. Actors in the value chain are here divided into two categories:

- **Primary actors**: those that satisfy customer needs in the material *supply* chain (i.e. input suppliers, producers, intermediaries, processors, distributors, exporters, vendors, end consumers);
- **Secondary actors**: Supporting services that add value to the chain (e.g. financial entities, government, R&D agencies, education institutions, insurers, NGOs, business associations.

In order to characterise the value chains using this methodological framework, information from semi-structured interviews with value chain actors collected between 2015 and 2017 was used. A total of 22 interviews were undertaken with primary value chain actors (i.e., input suppliers, producers, processors, distributors, retailers, end consumers and exporters) in the tilapia and ornamental fish value chain respectively (see Table 8). In addition, interviews responses were also collected from secondary actors (i.e., government officers, financial institutions, R&D agencies and education and academic entities). The interviews with value chain actors were complemented, whenever possible, by field visits: 10 field visits to tilapia fish farms and 12 to ornamental fish production sites, undertaken in 2016 and 2017 and later enriched through information collected during bilateral calls in April and May 2021.

Table 1 Summary of actors interviewed in the tilapia and ornamental fish industries

TILAPIA		ORNAMENTAL	
CATEGORY	**No. OF INTERVIEWS**	**CATEGORY**	**No. OF INTERVIEWS**
INPUT SUPPLIER	2	INPUT SUPPLIER	5
PRODUCER	16	PRODUCER	12
PRODUCER/PROCESSOR	1	DISTRIBUTOR	1
PROCESSOR/ DISTRIBUTOR	3	RETAILER	4
GOVERNMENT	6	GOVERNMENT	2
FINANCIAL INSTITUTION	5	FINANCIAL INSTITUTION	6
R&D / Training	2	R&D	1
FISH FARMER ASSOCIATION	2	EDUCATIONAL INSTITUTE	2

As part of the interviews, actors were requested to:

- Define their operations: size of the business (employees), equipment, and infrastructure;
- List all the relationships they currently hold in the value chain, in terms of interactions and exchanges of information, material and financial resources;
- Discuss key risks and concerns in their business, including climate change hazards;
- List key factors they considered hindered or enabled their ability to respond to external challenges (especially climate change stressors).

3.2 STEP 2: Characterization of climate hazards

A desk-based review of primary and secondary data was undertaken in order to define the nature and magnitude of climate hazards to which aquaculture value chains in Jamaica are exposed to. A series of reports exposing observed and projected climate changes in Jamaica and the broader Caribbean were consulted, including the "State of the Caribbean Climate Report (UWI 2021) and "The State od the Jamaican Climate" (PIOJ 2015).

In addition, information on Jamaican observed and projected climate hazard trends was drawn from the World Bank Climate Change Knowledge Portal and the Think Hazard portal and used to examine variability of climate hazards at the sub-national level.

In this assessment, climate hazards have been divided into two categories:

- Chronic climate hazards, referring to incremental climate changes, such as changes in temperature, rainfall patterns and sea level rise
- Acute climate hazards, referring to extreme weather events such as drought, heatwaves and extreme rainfall.

3.3 STEP 3: Qualitative assessment of climate hazard exposure and sensitivities along the tilapia and ornamental fish value chains

Drawing on the characterization of the two value chains (STEP 1) and the analysis of climate hazard exposures in Jamaica (STEP 2), a qualitative climate sensitive assessment of the two value chains was undertaken. This assessment defines climate sensitivity as the **proneness to damage** of an asset or value chain activity: how likely are value chain tiers to be affected by a particular climate hazard given their dependence on specific actors and resources.

Data to inform this step of the process was collected in two phases. First, drawing on the information collected through semi-structured interviews with value chain actors (stemming from the consultant's work on the value chains prior to this assignment) described in Section 3.1. This information was then enriched with information collected from value chain actors in two validation workshops undertaken in May 2021.

Having undertaken a qualitative analysis of value chain sensitivity across each value chain, an analysis of adaptation barriers and opportunities on each value chain tier was undertaken, drawing on information collected through the interviews and on desk-based research on adaptation measures taken in other aquaculture systems globally. Whilst this step of the process was not initially presented in the scope of the assignment, it was considered a key step to inform the analysis of National Fisheries Authority instrument and their ability to support (and lift barriers to) climate adaptation in the value chains.

In the context of this project, climate adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change and incorporates both the notion of coping capacity (i.e. the ability of a system to react to and reduce the adverse effects of experienced hazards) and that of adaptive capacity (i.e. the ability to anticipate and transform structure, functioning, or organization to better survive hazards).

3.4 STEP 4: Assessment of the plans and programmes by the National Fisheries Authority

Following the development and application of the climate sensitive value chain assessment framework and the identification of adaptation barriers and opportunities, a desk-based review of policy documents provided by the National Fisheries Authority was undertaken in order to determine whether existing plans and programmes tackle adequately climate change threats and opportunities in the tilapia and ornamental fish value chains.

The following NFA documents provided by the Aquaculture Division were examined as part of this review:

- Plan for Aquaculture Development 2012-2025
- Final Draft National Fisheries and Aquaculture Policy (2014)
- MOAF Operational Plan 2021-2022
- Approved Budget NFA 2021
- The Fisheries Act (2018)
- Capture fisheries and aquaculture in Jamaica: A sector review (2004)

In addition, the Aquaculture Division provided additional documents providing contextual background to the value chains under examination, namely:

- National Export Strategy for Aquaculture
- Hanson, T. (2008). Jamaica Tilapia Market Study: Final report

The review was undertaking through a 2-step process: first, by looking at the influence of NFA instruments along each tier of the value chain and secondly, by looking at the influence of NFA instruments on the overall enabling environment for private sector adaptation.

3.4.1 Assessment of NFA's support to adaptation along the value chain

This part of the assessment helped to determine what gaps in plans and programs remain in order to strengthen the resilience and competitivity of value chains tiers under a changing climate. During the review, areas of incidence of each plan and program were mapped against the different components of the value chain, in order to understand which components are well served by existing NFA's plan, and where gaps remain. The framework template that was used to undertake this assessment and which draws on information collected in Steps 3.1 to 3.3 is here illustrated in Table 2 and Table 3 below for the tilapia and ornamental fish value chains respectively.

Table 2 Components of the value chain assessment framework for the tilapia value chain

	Input suppliers	Primary producers	Higglers	Processors	Vendors	End Consumer
Actors						
Resources						
Activities						
Climate hazards						
Climate sensitivities						
Adaptation challenges						
Adaptation opportunities						
Final Draft Policy						
Aquaculture Development Plan						
Aquaculture Export Strategy						

Table 3 Components of the value chain assessment framework for the ornamental fish value chain

	Input suppliers	Producers	Local retailers	Exporters
Actors				
Resources				
Activities				
Climate hazards				
Climate sensitivities				
Adaptation challenges				
Adaptation opportunities				
Final Draft Policy				
Aquaculture Development Plan				
Aquaculture Export Strategy				

3.4.2 Assessment of the enabling environment

In the second part of the assessment, areas of incidenceof the NFA plans, programs and objectives were mapped against critical components needed to enable climate change adaptation within the private sector. The components of this assessment are drawn from the assessment framework for enabling private sector adaptation to climate change, developed by Crick et al. (2018), which conceptualisethe enabling environment as a set of four interacting "building blocks", namely: i) Policies and institutions; ii) Infrastructure, markets and ICT; iii) Data, information and capacity development; and iv) Financial environment. The core elements of the enabling environment are here Illustrated in Figure 2 below.

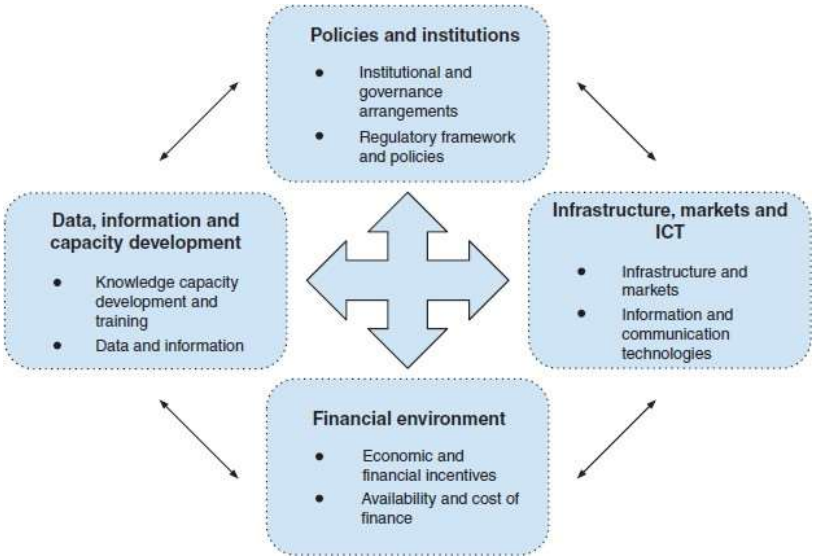

Figure 2 Core elements of an enabling environment for private sector adaptation and interlinkages across elements. Source: Crick et al (2018).

A good enabling environment facilitates adaptation processes within the private sector and can significantly affect the ability of value chain actors to adopt adaptation measures and to build value chain resilience.

Through this double assessment process, it is possible to understand which components of the existing NFA's policy and aquaculture development plan respond to adaptation needs in the value chains and where gaps remain.

3.5 STEP 5: Validation workshops with value chain stakeholders

Results from the preliminary value chain assessment were validated and refined with the National Fisheries Authority and with other members of the tilapia and ornamental fish value chains through the delivery of two workshops (one for each value chain). Having examined the travel regulations in times of COVID established

by the government of Jamaica[1] and explored options for flight arrangements, it was decided by both the consultant and the project team leader that the delivery of the workshops online would be a better option. Accordingly, an approach to successfully deliver the workshops online was suggested and approved by the team leader, which included:

- The preparation of a consultation document to be shared with workshop participants prior to the validation workshops, including closed end and open-end questions to solicit feedback to stakeholders on the framework proposed.

- Design and deliver two validation workshops remotely to present the framework proposed, explain the consultation document and facilitate a virtual discussion to collect preliminary feedback from the participants. Participants were given the option to join the event virtually, or to attend the virtual session in person, at the Aquaculture Division in Twickenham Park (Spanish Town). These workshops were held on the 27th and 28th of April for the ornamental fish and tilapia value chain respectively;

- Follow up with participants through bilateral meetings to help stakeholders respond to the consultation document;

- Review responses collected through the consultation document and analyse responses together with those collected during the virtual workshops;

- Present a summary of feedback received in the current report.

In total, 39 individuals attended the Ornamental Fish Value Chain Workshop, of which 19 attended in person and 20 attended virtually). Similarly, 29 individuals attended the Tilapia Value Chain Workshop, of which 11 participated in person and 18 virtually.

Results from the climate sensitive network value chain assessment network were presented, discussed and validated with stakeholders during the workshops. Outcomes from the discussions have been incorporated into the results presented in this report.

1 Regulations for travel in time of COVID can be found here: https://www.visitjamaica.com/travelauthorization/traveller-categories/

4. CHARACTERIZATION OF THE TWO VALUE CHAINS IN JAMAICA

4.1 Characterization of the tilapia value chain in Jamaica

In 2005-2006, when tilapia production peaked in Jamaica, there were a large number of intensive fish farms, serving the export market through the coordinated efforts of Aquaculture Jamaica Ltd., a local company that operated a mother farm model, providing feed and fingerlings to small-to-large fish farmers, and coordinating the process and export of the fish. AJL was then a subsidiary firm of Jamaican Broilers, importers of grain for the production of tilapia fish meals. In 2009 the tilapia industry collapsed, with the exit from the value chain of Aquaculture Jamaica Ltd. Since then, the industry has been broken down into small extensive farming operations serving a small and not well-structured local market. There is interest in the Fisheries Division and at the Aquaculture Division at the Ministry of Industry, Commerce Agriculture and the Fisheries (MICAF) to see this industry develop, to support food security efforts in the country, and to help reduce the increasing food import bill in Jamaica.

An Aquaculture cluster group had been established through the Private Sector Development Programme and with the support of the Jamaican Exporters Association, but this cluster has been dismantled as a result of reductions in productivity within the industry.

According to recent assessments undertaken by the Aquaculture branch (Pers. Comm. 2021), there are currently 79 active fish farmers in Jamaica, the majority with total acreage under production of 1-5 acres (see Table 1) and more than a quarter based in Hill Run (see Table 2).

Table 4 Tilapia fish farming, according to size

		Total acres	Currently under production
Subsistent	< 1 acre	7	13
Small	1-5 acres	50	47
Medium	6-20 acres	13	11
Large	>20 acres	7	6
	N/A	2	2
	TOTAL	**79**	**79**

Table 4 Number of tilapia fish farming, according to location

Parish - Area	Number of tilapia fish farmers	Parish	Number of tilapia fish farmers
St Catherine Lloyd's pen	8	St Elizabeth	2
St Catherine Bushy Park	8	Westmoreland	4
St Catherine - Hill Run	24	St Thomas	4
St Catherine - Knollis	1	Clarendon	4
St Catherine Nightingale/ Spring village	8	Portland St Mary	2
St Catherine Old Harbour	4	Hanover	2
St Ann - Hartlands	8		

Key weaknesses stem from monopoly on feed production (which affect quality and price of feed) and exposure to changes in international grain prices (see Text box 1 below). In addition, farmers are in a position of competition (i.e., a "race to the bottom") and face challenges marketing tilapia for local consumption.

Key opportunities could stem from: promoting R&D (e.g., induced Zoo and Phytoplankton blooms – specially for small fish, use of biofloc– for bigger farmers and the use of local ingredients for fish feed); use of renewable energy sources and the promotion of water efficient practices. In addition, affiliation to fish farming associations could be further promoted, differentiating associations by size of fish farms. Together fish farmers could focus their efforts on: Working as a group (coordination of farming activities across farms); Develop marketing strategy and R&D support, in partnership with government; Develop an understanding of funding opportunities, with technical assistance from government; Organise to leverage resources (e.g., for mini dam construction, to buying feed in bulk); Applying best practices for feed and water conservation.

Drawing on interviews undertaken by the consultant prior to this assignment, a value chain network map has been produced, describing the different interactions taking place among value chain actors in the tilapia value chain (see Figure 3 below). This network map Illustrates the existing flows of information, financial and material resources taking place among value chain actors for the industry and helps identifying central actors as well as resource bottlenecks along the chain.

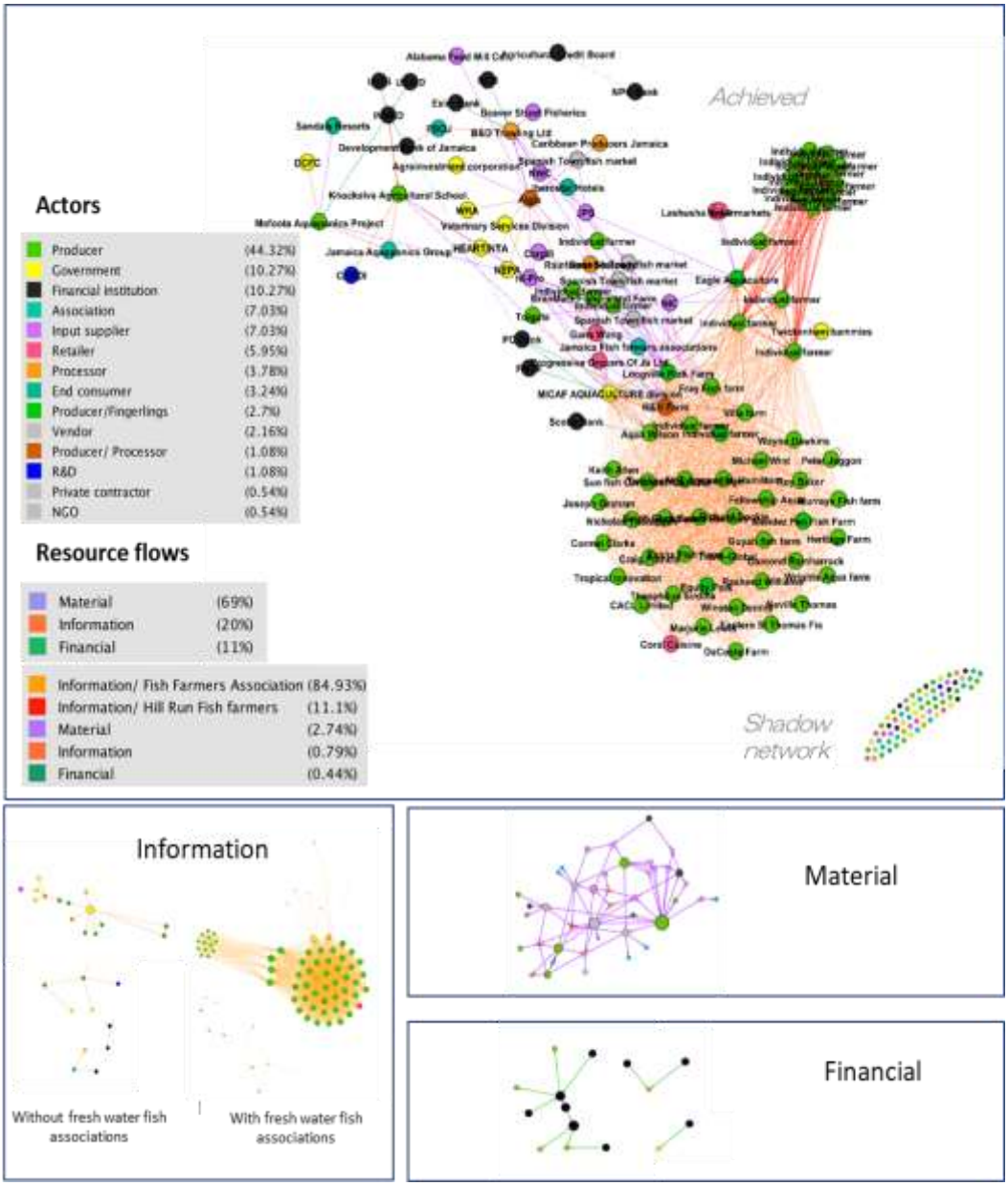

Figure 3 Value chain network map of the tilapia value chain. The different dotted colours represent the different actors along the value chain, whilst the different coloured lines reflect different types of resource exchanges. A differentiation is here made between the Information network that is achieved when fish farmer associations are active against the Information network that would exists in the absence of fish farming associations. Not all actors in the value chain were interviewed and hence not all linkages between all value chains actors could be mapped. For this reason, the "achieved network" here refers to the linkages that were mapped drawing on the interviews, whereas the "shadow network" refer to the set of actors that are known to be potentially part of the value chain, but that could not be linked to any of the networks from actors interviewed. Source: Canevari-Luzardo 2019.

4.2 Characterization of the ornamental fish value chain in Jamaica

The ornamental fish industry refers to the production of freshwater fish to be sold as pet fish in shops and aquariums and used in residential and commercial properties as decorative. Two categories of ornamental fish value chains are found in Jamaica: one that is export oriented and one focused on the local market. The first is an urban dwelling ornamental fish cluster, developed with the support of The Competitiveness Company since 2007, composed primarily of small facilities operated by marginal and poor communities in Kingston, and serving the export market. Here, the role of The Competitiveness Company is key: they provide training for construction and management of fish tanks as well as feed and fingerlings; they collect fish and package them according to standards and safety regulations; and they negotiate their export with international brokers.

The second group is represented by a smaller number of larger-scale fish farmers, who operate independently - outside of any cluster dynamic - and within a locally saturated market. An ornamental fish association exists, but has been inactive for a number of years. Most of the inputs to the value chain (e.g. fish feed, fish medications, tanks and decorations) are currently imported through two main local providers. According to recent assessments undertaken by the Aquaculture Division (Pers.Comm. 2021), there are currently 47 active fish farmers in Jamaica. The majority breed and grow the fish (see Table 3) on farms under 6,000sq.ft. (see Table 4) and most are located In Kingston (see Table 5).

Table 5 Ornamental fish farming, according to size

	Size of farm (sq.ft)	Total number of fish farms
Subsistence	100-500	6
Small	600-1000	12
Medium	1,100-6000	15
Large	>6000	9
	Unknown	5
	TOTAL	**47**

Table 6 Ornamental fish farming, according to location

Parish / Area	Number of tilapia fish farmers	Parish	Number of tilapia fish farmers
St Andrew - Kingston	22	St Catherine	11
Manchester	2	St James	1
St Catherine - Portmore	1	St Thomas	4
St Andrew	2	Trewlany	2
St Elizabeth	1	Unknown	1

Table 7 Ornamental fish farming, according to value chain operational typology

Category	Number of actors
Aquatic Plants/ Breeder Grower	1
Breeder /Grower	28
Breeder/ Grower/ Retailer	8
Breeder / Retailer	2
Grower	2
Importer / Vendor / Grower	1
Retailer	3
Unknown	2

Key strengths in the ornamental value chain stem from its close access and frequent airfreight to large markets (U.S. and Canada), which result in lower costs of shipping and lower death rates. Local climatic conditions also enable year-round production. In addition, local production Is relatively free of major disease.

The assessment by Gray and Jenson (2011) on the economic opportunity stemming from ornamental fish production In Jamaica concluded that " In analysing the results of the models, producing ornamental fish appears to be extremely profitable and a worthwhile investment for persons to venture in [...] To increase the chances of success, the investor must use the right combination of species in adequate quantities. 50,000 fish per month is the minimum quantify of fish that can be produced to make a profit. Given that at this quantity the business is susceptible to 10% fall in production or sales, it would be best to ensure that production is maintained at least 100,000 per month."

Key weaknesses in the ornamental value chain stem from: lack of consistent supply and volumes to satisfy major export markets; bureaucratic export procedures; lack of new broodstock; lack of investment and financial support to invest in R&D; lack of enough technical assistance and dissemination of best practices. In addition, as noted in the Plan for Aquaculture Development in Jamaica (2012-2025) "poor organization by eventual Jamaican exporters could completely prevent commercial access to the main US buyers/Importers, which for sure will not risk their credibility with these gigantic buyers, because of unpredictable events". Furthermore "unless Jamaican producers cluster and get well organized, export options will still be there, but out of reach".

Key opportunities for the sector could stem from: building promoting dialogue with local financial institutions interested in the sector; investigating alternative source of finance (e.g. social impact investment funds and the Green Climate Fund); promoting greater organisation among fish farmers.

Table 8 Characterization of the ornamental fish value chain

	Input suppliers	**Primary producers**	**Local retail**	**Exporters**
Actors	Water suppliers Electricity suppliers Fish feed suppliers Brood stock suppliers	Individual fish farmers	Local pet shops	Individuals
Resources	Primary resources (water, diesel, fish meal ingredients) Infrastructure and equipment	Water Animal feed Electricity Brood stock Antibiotics Infrastructure and equipment	Water Animal feed Electricity Antibiotics Live fish Infrastructure and equipment	Water Electricity Animal feed Antibiotics Live fish
Activities	Fertiliser mix development Energy generation, storage and distribution Water management	Ponds maintenance Feeding and monitoring growth	Manage stock (live) and sell	Feeding (live) Retail

Drawing on interviews undertaken by the consultant prior to this assignment, a value chain network map has been produced, describing the different interactions taking place among value chain actors in the ornamental value chain (see Figure 2). This network map Illustrates the existing flows of information, financial and material resources taking place among value chain actors for the industry and helps identifying central actors as well as resource bottlenecks along the chain.

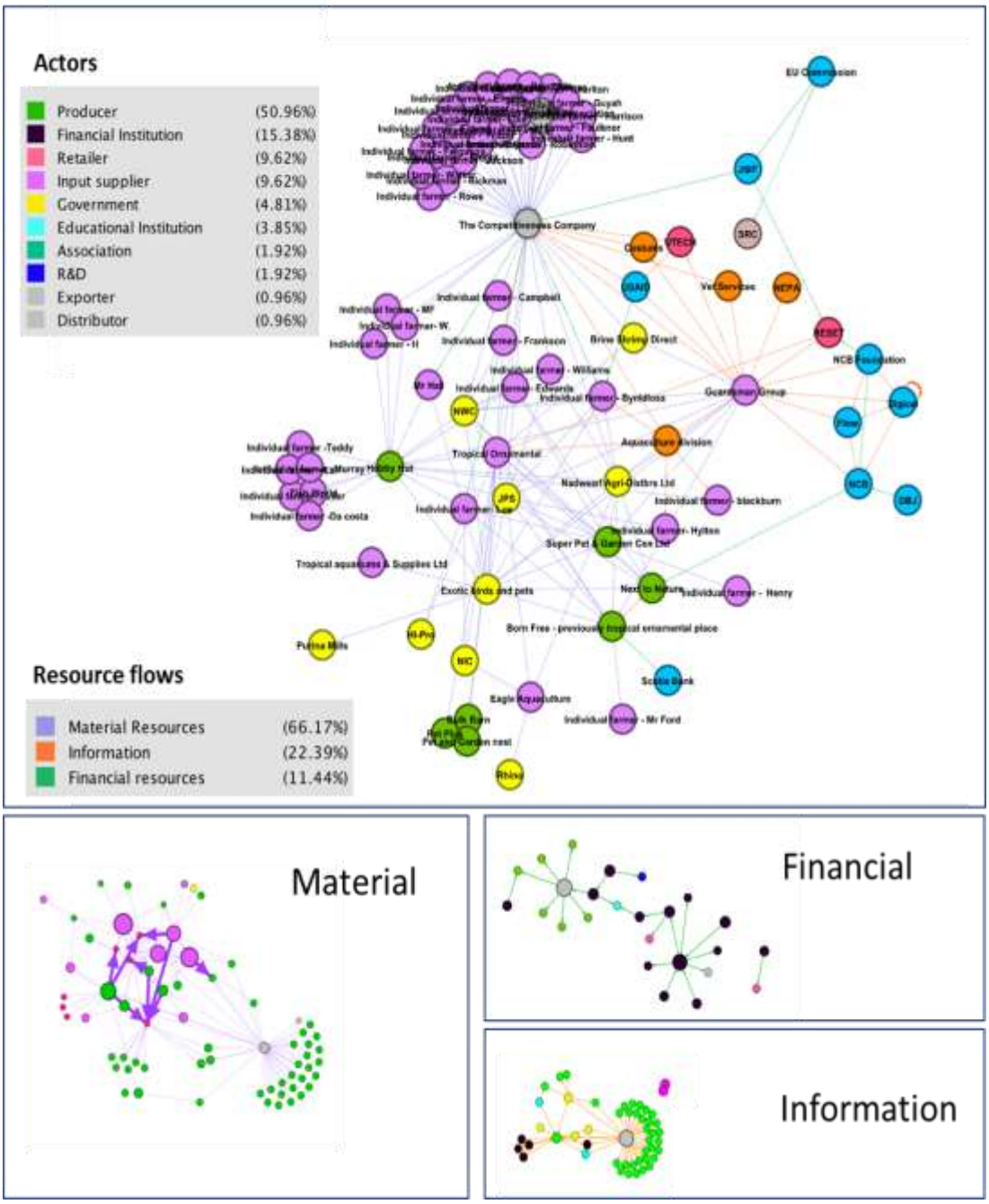

Figure 4 Value chain network map of the ornamental value chain. The different dotted colours represent the different actors along the value chain, whilst the different coloured lines reflect different types of resource exchanges. A differentiation is here made between the Information network that Is achieved when fish farmer associations are active against the Information network that would exists in the absence of fish farming associations. Not all actors in the value chain were interviewed and hence not all linkages between all value chains actors could be mapped. For this reason, the "achieved network" here refers to the linkages that were mapped drawing on the interviews, whereas the "shadow network" refer to the set of actors that are known to be potentially part of the value chain, but that could not be linked to any of the networks from actors interviewed. Source: Canevari-Luzardo (2019)

5. EXPOSURE TO CLIMATE HAZARDS

Jamaica's climate is characterized by dry winters and wet summers and it is strongly variant across the country according to orography and elevation. The main rainfall season is from June to November, with a temporary decline in rainfall around July, in what is known also as the midsummer drought (Chen et al., 2009). Inter-annual variability is strongly dictated by El Niño Southern Oscillation (ENSO) events: dryer years tend to occur under El Niño conditions, whilst wetter years occur under the influence of La Niña.

Analysis of observed meteorological records show a warming and drying trend across the entire region. For decades Jamaica has experienced below normal rainfall and severe droughts (especially in 2009-10 and 2014-16). Consistent with global rates, mean temperatures are increasing at a rate of 0.16 °C per decade, with minimum temperatures increasing faster (around 0.27 °C/decade) than maximum temperatures (around 0.06°C/decade) (Climate Studies Group 2017). In addition, mean precipitation levels have declined by 6.2mm and 4.5 per month per decade (in June-August and September-November respectively) (Selvaraju et al., 2013). As noted by USAID (2017), rising temperatures, increased evaporation and decreasing precipitation are reducing replenishment of underground water sources and groundwater recharge.

There has also been a regional increase in tropical storms, especially for hurricanes category 4 and 5; although evidence suggesting that this is due to increased surface temperatures and providing clear projections on future intensity and frequency of storms remains inconclusive.

According to the latest State of the Caribbean Climate Report (2020), the recent warming trend will continue in the future. Mean temperatures across the region are expected to Increase by 0.65°C -0.84°C by the 2030s, 0.86°C -1.50°C by the 2050s and between 0.8°C and 3.0°C5 by the end of the century, with the southern parts of the Caribbean showing a slightly higher warming trend than the rest of the region (Climate Studies Group, Mona 2020). In Jamaica, it is expected that maximum, minimum and mean temperatures will all increase, irrespective of which climate scenario is considered and across all seasons of the year (Climate Studies Group 2017).

In addition, the Caribbean as a whole is expected to gradually dry out and drying is expected to be more intense in the south and south east of the region, particularly in the late wet season (September-November). In the central and southern areas of the Caribbean basin, Regional Climate Models (RCM) suggest a 25-35% decrease in rainfall by the end of the century (Climate Studies Group, Mona 2020). For Jamaica, regional circulation models project a drying trend from the mid-2030s which will likely continue through to the end of the century (Climate Studies Group 2017). The 2030s will be up to 4% drier, the 2050s up to 10% drier, while by the end of the century it is expected that as a whole the country may be 21% drier under the most severe RCP climate scenario (RCP 8.5).

Table 9 Observed and projected changes in climate variables. Source: State of the Caribbean Climate report

Historical trend	Projection
RAINFALL Decadal variations account for 7% of the observed variability in Caribbean rainfall. Year-to-year (interannual) variations account for up to 91%. The number of consecutive dry days is increasing, as well as the amount of rainfall during rainfall events.	**RAINFALL** The Caribbean as a whole will gradually dry through to the end of the century. Drying is expected to be less in the far north Caribbean and more in the south and southeast. Global Climate Models (GCMs) suggest for the central and southern Caribbean basin, drying up to 20 per cent for annual rainfall, while Regional Climate Model (RCM) based projections suggest up to 25 and 35 per cent less rainfall by the end of the century
AIR TEMPERATURES Increase in temperature in Caribbean is consistent with global warming trend. There is an increasing trend in very warm days and nights for the Caribbean as a whole.	**AIR TEMPERATURES** Projections based on statistical downscaling show an increase for both warm days and warm nights by the end of the century - warm days ranged between 51 and 251 days, and warm nights between 24 and 360 days for RCP 8.5. » The trend is for a decrease in both cool days and nights. The range for cool days was between 1 and 41 days, and between 1 and 32 days for cool nights for the end of century under RCP 8.5
SEA SURFACE TEMPERATURES Range from 25°C to 30°C over the period of the year and follows a normal distribution pattern with the lower temperatures in December/January and the highest temperatures in July.	**SEA SURFACE TEMPERATURES** Recent warming trend in SSTs will continue in the future. Under a business-as-usual scenario, SSTs increase by 1.76 ± 0.39°C per century in the wider Caribbean. The mean annual SST range (~ 3.3°C) currently observed in the Caribbean Sea is projected to contract to 2.9°C in the 2030s, and to 2.3°C in the 2090s. By the end of the century, years of coolest projected SSTs fall within the range of the warmest years in the present.
SEA LEVELS A regional rate of increase of 1.8 ± 0.1 mm/year between 1950 and 2009. Higher rate of increase in later years: 1.7 ± 1.3 mm/year between 1993 and 2010.	**SEA LEVELS** For the Caribbean, the combined range for projected SLR spans 0.26-0.82 m by 2100 relative to 1986-2005 levels. The range is 0.17-0.38 for 2046 – 2065. Other recent studies suggest an upper limit for the Caribbean of up to 1.5 m under RCP8.5.
HURRICANES Significant increase in frequency and duration of Atlantic hurricanes since 1995. Increase in category 4 and 5 hurricanes; rainfall intensity, associated peak wind intensities mean rainfall for same period.	**HURRICANES** Shift toward stronger storms by the end of the century as measured by maximum wind speed increases of +2 to +11%. +20% to +30% increase in rainfall rates for the model hurricane's inner core. Smaller increase (~10%) at radii of 200 km or larger. An 80% increase in the frequency of Saffir-Simpson category 4 and 5 Atlantic hurricanes over the next 80 years using the A1B scenario.

It is important nonetheless to note that some parts of the country are expected to become warmer and drier than others (see summary maps of expected changes in mean annual temperature and percentage change of rainfall in Figure 3). Accordingly, by the end of the century, we can say that the tilapia fish farms that will be most exposed to higher increases

in temperature will be those located in St Catherine (+3.76°C), Clarendon (+3.74°C) and between Saint Ann and Saint Mary (+3.90°C). In addition, by the end of the century, tilapia fish farms will have a higher exposure to changes in annual rainfall (%) if they operate within the parishes of St Catherine (-37.03 %), between Saint Mary and Portland (-28.09%) and Clarendon (-24.47%). Similarly, by the end of the century, the ornamental fish farms that will be most exposed to higher increases in temperature will be those located in St Catherine (+3.76°C), Manchester (+3.65°C) and the northern side of Saint James (+3.62°C). Accordingly, those that will be exposed to greater reductions in rainfall will be those located within the parishes of St Catherine (-37.03°C), Saint Andrew and Kingston area (-28.52%) and Saint Thomas (-25.20%).

Although an increase in the frequency of hurricanes is not projected, there in a shift towards stronger storms by the end of the century and a projected increase of 80% in the frequency of Saffir-Simpson Category 4 and 5 Atlantic hurricanes (Climate Studies Group 2017).
Finally, as it pertains to sea level rise (SLR), all models suggest a mean projected SLR in Jamaica of 0.58 to 0.87m by the end of the century and a maximum rise of 1.04m.

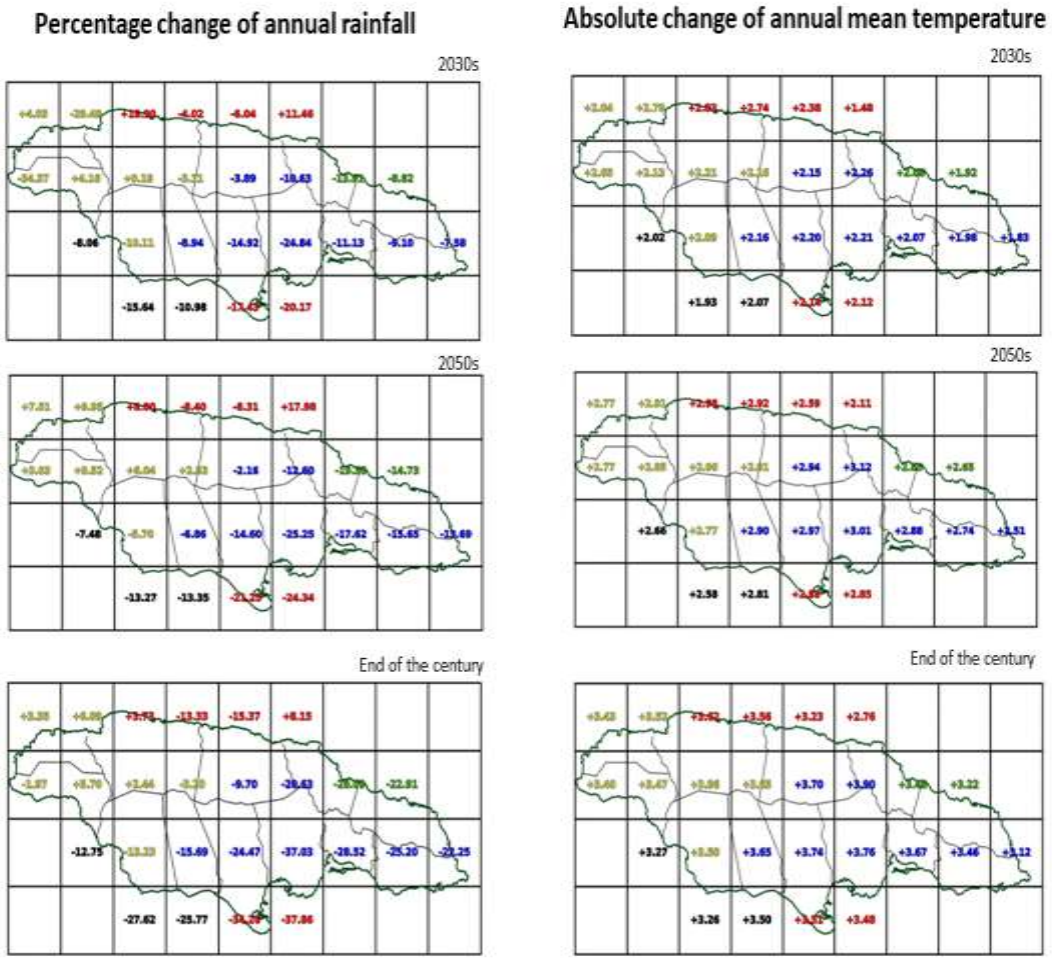

Figure 5 Left hand side: summary maps of percentage change per grid box of annual rainfall for 2030s, 2050s and end of the century. Source: PRECIS (Climate Studies Group 2017) Right hand side: Summary of maps showing absolute change per grid box of annual mean temperature (°C) for 2030s, 2050s and end of the century. PRECIS (Climate Studies Group 2017)

6. QUALITATIVE ASSESSMENT OF CLIMATE SENTITIVITIES IN THE TILAPIA AND ORNAMENTAL FISH VALUE CHAINS

The impacts of climate change in aquaculture in Jamaica and within the broader region are projected to be substantial under a 1.5 °C scenario, and likely to exacerbate under 2°C warming (Thomas and Benjamin, 2018). As noted by FAO, changes in the aquatic system caused by climate change will affect fisheries and the aquaculture sector throughout their whole value chains. Changes in species productivity and fish growth rates resulting in reductions in yields are already being observed, as well as damages to infrastructure (e.g., processing and storage areas) and loss of product at the fish farm due to extreme weather events (FAO 2018).

Studies on the effects of climate change in tilapia aquaculture show that fish farms exposed to floods and extreme hot weather are more likely to experience higher fish deaths and stress that reduce feeding and growth rates. Similarly, fish farms in areas exposed to drought and colder weather showed to be affected by disease outbreaks and reduced feeding rates (Pimolrat et al. 2013). According to a recent study undertaken in Northern Thailand, risks to tilapia production in earthen ponds can be divided into five categories[2]:

1. **Risks from high water temperatures during the summer:** During the summer months, when the days are long and direct heating from the sun is at its greatest, the water in ponds become separated into thermal layers; with the warmest - as high as 33 degrees Celsius - located at the surface of the pond. The primary effect of thermal separation is a decrease in the pond's overall oxygen content; effectively making the pond inhospitable for the fish. Furthermore, high water temperatures encourage the disintegration of organic matter, and can result in the release of aluminium, which could lead to a harmful accumulation. Combined, the effects of decreased oxygen and water poisoning, will suppress the fish's appetite, induce stress, and ultimately lead to a premature death.

   Water temperature ranging from 27-32°C is considered to be the most effective for rearing of Nile tilapia juveniles and fries, and higher temperature (>32°C) results in slow growth, reduce feeding efficiency and increase mortality

[2] Source:Aquadapt. Effects of climate change on rearing tilapia in earthen ponds. Aquaculture and Adaptation to Climate Change in Northern Thailand. Available at: https://idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/55973/IDL-55973.pdf

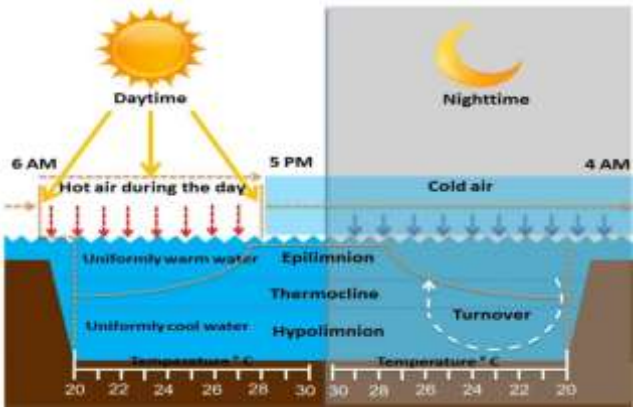

Figure 6 Thermal layering of the water during summer. Source Aquadapt

2. **Risks from low water temperatures during the winter** Less sunshine during the winter months means that the water in ponds remain relatively cool throughout the day; and drop at night. The effect of this on the fish is poor appetite; as cold temperatures interrupt the fish's normal digestion. In consequence, inadequate nutrition intake leads to poor growth, and therefore requires the farmer to extend the rearing period.

3. **Risks from floods** During the rainy season, surplus rain water could cause the ponds to become flooded. This is especially true in lowland areas, such as lower Northern Thailand, and upper Central Thailand; two regions that often have to contend with flooded ponds after extended periods of rain. Flooding can cause extensive damage to the ponds. Not to mention that the fish can escape and therefore produce a lower yield for the farmers, or on the other hand, introduce other aquatic life that could disrupt the original system

4. **Risks from droughts:** During drought season, farmer's often face the difficulty of how to replenish water in their ponds. This is especially true for farmers with ponds outside irrigation areas or are located far from water wells. Ponds rearing large fish are also more prone to risks, since less water and a hot climate will have an effect on the temperature and composition of the water, in turn encourage plankton growth; which can diminish water quality. Poor water quality implies an unsuitable living environment, which might lead the fish to become stress, weak, and eventually die.

5. **Risks from low oxygen content in ponds during the rainy season:** During the transition period between summer and the rainy season, farmers are often faced with the dilemma of dying fish, due to lack of sufficient oxygen content, this, and the fact that Aluminium sediments become mixed into the water. The main contributing factor to oxygen content in a pond is exposure to sunlight; whence oxygen is created and stored during the daytime and used at night. During the transition period between summer and the rainy season, photosynthesis is limited, since clouded skies prevent optimal synthesis of oxygen. Therefore, less oxygen is available for the fish to use during the night. In addition, if it rains, this will cause the water temperature to drop, in turn, stir up the water and cause sediments to be distributed throughout the pond. Thus, farmers rearing large fish often have to contend with dying fish during this seasonal transition period.

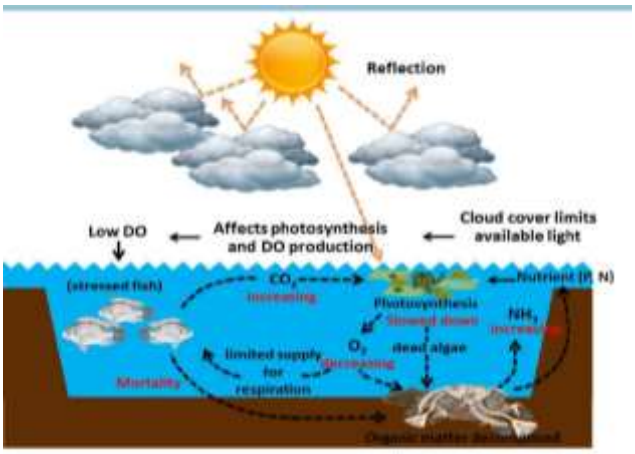

Figure 7 Risks from low oxygen content in ponds during the rainy season. Source: Aquadapt

Due to the impacts of climate change and over-exploitation on marine catches, it is expected that growth for aquatic food supplies to meet current and future demand of fish products will have to come mainly from aquaculture; hence, the imperative need to understand and manage climate risks to this sector (FAO 2018).

It is important to also note that Jamaica is not only exposed to climate risks affecting the country, but also to transboundary climate risks generated through trade, which make Jamaica vulnerable to climate risks triggered in other parts of the world. For example, climate impacts on crop production affecting the price of grains globally have shown to have significant repercussions on the price of fish meals, which can have devastating consequences in aquaculture production. The impacts of transboundary climate risks to the tilapia and ornamental fish value chains are examined in the text boxes 1 and 2 respectively.

Text box 1 Exposure to transboundary climate risks in the tilapia fish value chain: a reflection on the impacts of the 2007 world food crisis

Between 2007 and 2008 there was a fast and significant increase in food prices throughout the world, particularly in the price of grains. This surge was generated by a number of factors, including: lower yields caused by unfavourable weather conditions (Headey and Fan, 2010),3 an increase in the demand for cereal crops worldwide and an increase in oil prices (Headey and Fan, 2010; FAO, 2009). The impacts generated by lower yields were further augmented by actors' responses to the food crisis, in particular governments' implementation of trade restrictions (Challinor et al., 2018; Headey and Fan, 2010), and financial speculation (Headey and Fan, 2010).

Prior to the global food crisis, the conditions for domestic aquaculture production in Jamaica (tilapia fish farming in particular) were already challenging, defied by the increase in the availability of cheaper imported fish, rising costs for electricity, predial larceny and a lack of a marketing strategy for the industry (Wurmann, 2011). In addition, conditions for export were also difficult: the sole exporter of tilapia to Europe and North America was Aquaculture Jamaica Ltd (AJL), which run two farms and contracted additionally farmers to which it supplied fingerlings, feed, and technical assistance (Wurmann, 2011; Watanabe et al., 2002). But the conditions in the export market were very competitive. As noted by a representative from AJL (Pers. Comm. 2017): "we were competitive because we could deliver fresh fish within 48 hours of harvest, but the price was capped by price of competing captured fish. There is a market premium for fresh fish, but within a limit."

[3] Prices were also affected by later events in 2012, in particular a heatwave in Russia and a severe drought in the U.S.

Up to 2006, AJL had managed to sustain its export market, although within relatively low profit margins. Its business model, however, was not prepared to endure the price spikes preceded by the 2008 world food crisis. Since cereals are the main source of carbohydrates in most fish meals (FAO, 2009) and fish meal accounts, on average, for up to 50% of the cost of production in aquaculture (FAO, 2009), an increase in the price of cereals can have serious and detrimental effects on aquaculture production. In Jamaica, under normal conditions, fishmeal prices would range between US$500 and US$700 per Ton (2000-2005); however, and as a result of the spike in grain prices during the wolrd food crisis, price for fish feed in Jamaica increased by 116.3%" (Sofreco, 2012). Competing against captured fish on the shelf meant AJL could not increase its price for tilapia, despite the increased costs of production, as most households would be unwilling to pay a higher premium in light of cheaper fish substitutes (Wurmann, 2011). Consequently, with profit margins already low, the increase in costs was simply too much for AJL to absorb: As noted by the representative from AJL "Margin [was] very thin; single digit. When margins turned negative in foreign exchange - that meant no business for us."

The company first downsized by cancelling its exports to Europe and North America, losing some 50% of its market and flooding for a short period the local market for fresh tilapia. Not being able to recover from the hit, the AJL's mother company (i.e. Jamaican Broilers) lost interest and sold AJL assets and infrastructure. The industry changed radically and very rapidly: many fish farmers left the industry along with AJL, and those that remained changed their practices from intensive (with the use of electrically oxygenated water pumps) to extensive or small semi-intensive operations. Lacking cooperation and coordination between their activities, the remaining farmers were consequently engaged in a race to the bottom and despite the steady increase in aquaculture farming globally, the production in Jamaica went from 8,000 Ton in 2006 (Wurman 2012) to under 700 in 2017 (Aquaculture Division, Pers.Comm. 2017).

It can therefore be inferred that reliance on imported grains for fish meal production and lack of local feed substitutes had exposed the value chain to transboundary climate risks, making it vulnerable to potential changes in international grain prices and to the world food crisis.

Text box 1 Exposure to transboundary climate risks in the ornamental fish value chain: what could happen to the salt lakes?

Most actors in the Jamaican ornamental fish value chain have as their main supplier of brine shrimp artemia the company Brine Shrimp Direct, which runs its operations from the salt lakes in Utah. In periods of El Niño events, higher precipitation over the salt lakes results in a reduction of water salinity. Below 80gm per litre or 80ppt, predators of artemia can recolonise the lake reducing artemia production.

On the other hand, decreasing rates of precipitation associated with climate change can lead to lower levels of water volume and hence in the availability of habitat for artemia growth. Changes in precipitation and increasing temperatures and evaporation rates can be a cause of concern for the water quality for the Salt Lakes.

Given the reliance on imported artemia from the Salt Lakes, climate impacts in Utah's Salk Lakes could become a source of transboundary climate risks to ornamental fish production.

Terminal lakes are highly susceptible to climate change impacts since water that enters through precipitation, runoff, and groundwater must be balanced with water that leaves through evaporation. A change in this equation can lead to a decline in elevation, which can be tragic for the ecosystem, particularly if the closed basin is shallow. Great Salt Lake faces many threats that will impact the volume of water in the depression of the Bonneville Basin where it resides. If the lake's level declines, salinity increases, and wetlands are altered. Salinity is a driver of microbial diversity and, as this foundation of the ecosystem is altered, so will be the rest of the food web, affecting large numbers of avian migrators along the Pacific and Central fly-ways. Human population growth and water diversions for agriculture have put a strain on Great Salt Lake, resulting in a terminal lake whose trajectory is downward in surface area. How might anthropogenic climate change impact this scenario? Alterations in temperature can influence the timing of snowmelt and change evapotranspiration. As temperatures increase and droughts persist, climate change will amplify the decline in lake elevation, creating more

dust from the exposed lakebed. Dust blowing into inhabited valleys will worsen air quality with particulates and may be laden with the pollutants collected by the lake. Early melting of the snowpack in the Wasatch Mountains due to higher temperatures would be further impacted as airborne dust from the dry shorelines is deposited during storms and can reduce the albedo of snow, altering groundwater recharge of the watershed. The current status of Great Salt Lake, with no water rights of its own and increasing pressures for water use upstream, does not bode well for the survival of this critical ecosystem given climate change predictions for the southwestern United States.

In responding adequately to local and transboundary climate threats, Jamaica has a unique opportunity to better position itself in the international tilapia and ornamental export market and to increase production for domestic consumption (in the case of tilapia). But this requires strategic measures to be taken by government in order to anticipate climate risks and increase the adaptive capacity of aquaculture in Jamaica in order to increase its resilience and competitive advantage in the face of climate change.

It is therefore imperative to undertake a climate sensitive assessment of aquaculture production in the tilapia and ornamental fish industries in order to better understand the direct, indirect and transboundary climate risks that the sector is exposed to. The following sections summarize the results of the analysis on climate sensitivities, adaptation challenges and opportunities along the tilapia and ornamental fish value chains. The results provided have been enriched and validated by stakeholders during the two workshops held in May 2021.

6.1 Assessment of climate sensitivities along the tilapia value chain

	Input suppliers	Primary producers	Higglers/intermediary	Processors	Vendors	End Consumer
Actors	Land agency Water suppliers Electricity suppliers Fish meal suppliers Brood stock suppliers	Individual fish farmers	Individuals	Processing companies	Individuals	Hotels Restaurants Shops Householders Supermarkets
Resources	Primary resources (water, diesel, fish meal ingredients) Infrastructure and equipment	Water Animal feed Electricity (semi-intensive) Brood stock Antibiotics Infrastructure and equipment	Transportation Capital to purchase live fish	Water Animal feed Electricity Antibiotics Infrastructure and equipment	Water (live fish) Electricity (live fish) Live fish Infrastructure and equipment	Store Infrastructure and equipment
Activities	Fish meal development Energy generation, storage and distribution Water management	Ponds maintenance Feeding and monitoring growth	Collect and transport fresh and live fish	Chill kill Scaling Gutting Seasoning	Retail	Stock and sale
Climate hazard exposure	Drought Floods	Drought High Rainfall and Floods Temperature increases Strong winds	Floods	Drought Floods Hurricanes	Drought Floods Hurricanes	Floods Hurricanes
Climate sensitivities	Water utility providers are vulnerable to water shortages during dry periods During extreme events such as hurricanes, electricity poles can be damaged and destroyed preventing access of electricity to the end user.	Extensive, green water and open water earthen pond aquaculture systems are more susceptible to drought due to high evaporation rates. Tilapia have an optimal temperature range outside of which the fish do not feed, grow and reproduce optimally. High/Low temperatures affect water quality and lead to fish eating less and becoming weaker. Extreme heat leads to lower levels of dissolved oxygen, therefore fish will die if stocked too heavily - need more water to cool the pool. Low water temperatures reduces fish appetite and interrupt normal fish digestion. High rainfall can affect access to ponds Strong winds can result in loss of fish meal during feeding times Flooding of ponds can damage the ponds and result in fish loss Invasive water weeds and more aggressive species Sea level rise can lead to saline intrusion	Heavy rainfall and associated flooding can affect road infrastructure and access to farms and to markets	Hurricanes can result in damage to infrastructure Increased temperatures lead to increase cost of electricity	Reliance of freshwater for live fish makes them susceptible to drought During hurricanes facilities can be affected by power blackouts increasing fish mortality	Heavy rainfall can result in flooding of retail facilities Hurricanes can result in damage to infrastructure

6.2 Assessment of climate sensitivities along the ornamental fish value chain

	Input suppliers	Primary producers	Local retail	Exporters
Actors	Water suppliers Electricity suppliers Fish meal suppliers Brood stock suppliers	Individual fish farmers	Local pet shops	Individuals
Resources	Primary resources (water, diesel, fish meal ingredients) Infrastructure and equipment	Water Animal feed Electricity Brood stock Antibiotics Infrastructure and equipment	Water Animal feed Electricity Antibiotics Live fish Infrastructure and equipment	Water Electricity Animal feed Antibiotics Live fish
Activities	Fertiliser mix development Energy generation, storage and distribution Water management	Tank, pond and housing infrastructure maintenance Feeding and monitoring growth	Manage stock (live) and sell	Manage stock (live) Retail
Climate hazard exposure	Drought Floods Hurricanes Changes in rainfall patterns	Drought Floods Temperature increase	Drought Hurricanes Floods Changes in rainfall patterns	Drought Floods Hurricanes
Climate sensitivities	Water utility providers are vulnerable to water shortages during dry periods	During hurricanes facilities can be affected by power blackouts increasing fish mortality High wind can also damage housing infrastructure Despite access to water recycling in circular fish tank systems, lack of freshwater in times of drought poses a problem	Reliance of freshwater for live fish makes them susceptible to drought During hurricanes facilities can be affected by power blackouts increasing fish mortality	Value chain disruptions caused by bad weather, generating export delays

7. ASSESSMENT OF ADAPTATION CHALLENGES, OPPORTUNITIES AND SUPPORT PROVIDED BY THE NFA'S INSTRUMENTS TO AQUACULTURE VALUE CHAINS IN JAMAICA

The review of NFA documents shows that current strategies have set out objectivesthat help to respond to climate change adaptation challenges and opportunities along the two value chains under review (i.e., tilapia and ornamental fish). However, given that the policy and strategy set out objectives (rather than activities) and thata performance evaluation review has not yet been completed for either, it is challenging to assess in this report whether the activities of the Aquaculture Division are on track to fulfilling these objectives. For these reasons, and in order to enrich this review, it is recommended that the Aquaculture Division undertake a quick exercise to produce an express report of the activities under operation and in the pipeline for this year, to better appraise if the activities of the Aquaculture Division are helping to tackle adaptation challenges and where major gaps remain.

From the initial review, it is nonetheless possible to draw preliminary conclusions and offer key reflections on key areas that could be further strengthen.

7.1 Assessment of adaptation challenges, opportunities and NFA's policy and Aquaculture Strategies' incidence along the tilapia value chain

From the analysis of objectives and activities described in NFA documents (i.e. the Aquaculture Policy and the Aquaculture Development Plan) and in the Aquaculture Export Strategy (JAMPRO 2014) it can be inferred that these NFA instruments offer support to lift barriers to adaptation across different components of the tilapia value chain. Most predominantly, existing plans and policies offer support to fish farmers, whilst the number of activities in support of other value chain components remain limited. Table 10 summarises the key adaptation challenges and opportunities across each tier of value chains operations and describes how the NFA documents (i.e. the Aquaculture Policy and the Aquaculture Development Plan) and in the Aquaculture Export Strategy (JAMPRO 2014) provide entry points of support to climate change adaptation within the value chain.

Table 10 Assessment of adaptation challenges, opportunities and NFA's policy and Aquaculture Strategy objectives incidence along the tilapia value chain

	Input suppliers	Primary producers	Higglers/intermediary	Processors	Vendors	End Consumer
Adaptation challenges	Building the business case for improving water efficiency use Reducing water abduction and system losses Quality broodstock	Increasing inputs prices as feed, labour and energy. Dependence on internationalcommodity prices. Lack of adequate extensionservices. Lack of access to credit. Inadequate access to water in high production areas such asHill Run. Inadequate supply of seedstock. Praedial larceny. Poor organization of producers(race to the bottom). Finite land space and suitablesoil type.	Poor infrastructure Linked to General ServiceSupporting schemes (e.g.,road development).	Shortage of local suppliers and lack of steady supply Much of the processing and distribution infrastructure needs to be upgraded and very few have rigorously documented systems and procedures in a format that can meet the quality systems requirements for export or even supply to some of the international hotels. (Aquaculture strategy) The handling systems used by the distribution and transport elements of the value chain and the retail end (the vendors) also needs upgrading in both their physical status and quality systems and practices as well.	Shortage of local suppliersand lack of steady supply. Lack of local consumption.	Lack of local consumption.
Adaptation opportunities	Diversify imported input sources for feed Develop local feed substitutes Stockpile produced/imported input sources Improve broodstock/ quality of fries Rehabilitation of idle ponds Changes in duties for imported materials (e.g. feed for juvenile fish, ingredients for feed) Reduce competition with food imports (e.g. Tariffs ; local fuel subsidy) Reduce entry barriers (e.g. lower duties on imported equipment) Increase competition of food supply Promote certification of fish hatcheries to supply quality fry	Pumping /oxygenations (air flow cheaper than mechanical pump) Update feed management practice Implement local monitoring and early warning systems and research Improve access to water Reduce cost of energy /improve access to alternative energy sources Improve provision of extension services and R&D Improve access to credit Improve access to good land Improve critical infrastructure Increase depth of water ponds Develop new financial models (e.g.value chain guarantees) Improve access to credit Improve water management at the catchment level Reduce competition with food imports Mini dams- on site storages. For new farms: Promote risk-based zoning Fingerlings in contained areas, grow them to bigger size and then put back in the ponds to reduce the risk of fish loss Water recycling).		Promote value added products Reduce energy costs with the use of renewables (e.g. solar ice makers, solar cold rooms)	Increase resilience to price spikes (increase wealth) Improve marketing Establish the local demand for tilapia and correlate that with the current production	Increase resilience to price spikes (increase wealth) Improve marketing Establish the local demand for tilapia and correlate that with the current production

	Input suppliers	Primary producers	Higglers	Processors	Vendors	End Consumer
Policy	Promote accessibility of affordable and quality feeds, as well as other critical inputs (such as energy, land, water supply, security) to improve the competitiveness of the aquacultureindustry.	Strengthen and build capacity of fish farmers andrelated producer organizations to effectively participate in the value chain.		Create an enabling environment that facilitates and promotes the development of value added, including processing technologies, ofexisting fish and fishery products and encourage the development of new ones, particularly for unutilized and underutilized fisheries.	Promote collaboration among stakeholdersin the value chain for the marketing and distribution of fish and fishery products.	Promote greater consumption of fish and fishery products by increasing public awareness and education ontheir benefits and wholesomeness.
	Encourage adoption of appropriate practices in the genetic improvement of aquaculture products, including brood stock.	Establish collaborative mechanisms with allstakeholders to reduce praedial larceny on fish farms.		Cooperate with the fishing industry in order to facilitate the production of value-added products.	Enhance the mechanisms to facilitate the development of a more organized and efficient marketing and distribution system for fish and fishery products.	Ensure that rules, regulations and administrative procedures applicable to trade in fish and fishery products are clearand user friendly and the mechanisms are efficient without jeopardizing their effectiveness.
	Develop appropriate mechanisms to monitor the impacts of inputsused in aquaculture.	In collaboration with relevant stakeholders, explorealternative energy solutions for fish farms in order to reduce energy costs to fishfarmers.		Research and development activities in value added fish products will be encouraged by stakeholders and other research institutions. Public/private partnerships will therefore be integral to this thrust.		
	Develop and implement a registration and licensing system foreffective administration and planning for aquaculture.	Develop local standards and codes of good practicesfor aquaculture facilities.		Explore the possibility of fiscal incentives to private sector entities that engage in value added processing of fish and fishery products.		

	Input suppliers	Primary producers	Higglers	Processors	Vendors	End Consumer
Policy		Establish effective procedures specific to aquaculture to undertake appropriate environmental assessment and monitoring, with theaim of minimizing adverse ecological changes and related economic and social consequences.		Establish GMPs for the fish processing sector, which must be taken into consideration when formulating rules and regulations to governthe sub-sector.		
		Develop mechanisms to assist producers in accessing markets for their fish and fishery products.		Collaborate with relevant stakeholders to research, develop and invest funding into green technology such as supplemental wind and solar power for processing plants, and vessel designs orpowering to reduce fossil fuel consumption.		
		Promote best practices in pre and post-harvesthandling and management in the aquaculture sector.				
		Develop local standards for fish farms in conjunction with farmers and relevant regulatory agencies and require fish farms to meetthese standards before certification. Develop codes of best farming practices, for e.g.GAPs				
		Encourage aquaculture facilities to improve management practices with a view to the introduction of relevant international and localphytosanitary and sanitary standards (e.g. GAP).				
		Identify, and where possible, develop alternative livelihood opportunities for fishers, fish farmers and other vulnerable groups in the coastalzone to build resilience and reduce vulnerability.				

	Input suppliers	Primary producers	Higglers	Processors	Vendors	End Consumer
Aquaculture Export Strategy	Introduction of new broodstock	Technical and professional competency andeducation to improve farm practices Technical and professionalskills in farm practices improved.			The monitoring of enterprises to ensure the compliance is maintained is important and will have to be resourced. In addition to the quality of local production, qualitycontrol at the borders is also critical.	The industry could certainlybenefit from information onmarket opportunities, and especially on market entry requirements and strategies
Aquaculture Development Plan	Continuous improvement of fish quality through genetic selection programs.	Actions should be undertaken to cluster producers working in the same regions or zones, to facilitate access to them in many respects.				
	Feed manufacturers should be encouraged to stick to raw materials compatible with the supply of adequate protein contents, but, always keeping in mind digestibility as their main concern.	Joint planning and buying of raw materials, such as feed				
	Implementation of traceability programs, certification of water quality and/or of environmental impacts, managerial and logistic aspects	Alternative sources of supplies should be developed, either in Jamaica, or from foreign countries. These new sources should guarantee minimum sales levels to farmers, at agreed upon prices and qualities				
		To control the quality of raw materials bought, activities should be planned and defined by farmers, with help of specialized consultants.				
		Producing 'organic fish' as a means of having access to a growing world market for organic food.				
		Chinese firms can bring in technology and new knowledge from their own country to Jamaica, enhancing aquaculture prospects				

7.2 Assessment of adaptation challenges, opportunities and NFA's policy and Aquaculture Strategies incidence along the ornamental fish value chain

From the analysis of objectives and activities described in the Aquaculture Policy, the Aquaculture Export Strategy and the Aquaculture Development Plan, it can be inferred that these NFA instruments offer limited direct support to ornamental fish farming, although several of the objectives presented in Table 10 above support aquaculture activities more in general.

Table 11 summarises the key adaptation challenges and opportunities across each tier of value chains operations for ornamental fish production and describes how the Aquaculture Policy, the Aquaculture Export Strategy and the Aquaculture Development Plan provide entry points of support to climate change adaptation within the value chain.

7.3 Assessment of adaptation challenges, opportunities and NFA's policy and Aquaculture Strategies incidence along the ornamental fish value chain

Building on the work of Stenek et al. (2013), Crick et al (2018) developed a framework to evaluate critical factors enabling private sector adaptation to climate change, divided into 4 key elements of an enabling environment, namely: i) Data, information and capacity development; ii) ii) Infrastructure, markets and ICT; iii) Financial environment; and iv) Policies and institutions. This framework helps to understand how different policy and government strategies and objectives can support the development of conditions at the national and sub-national levels that can support climate change adaptation within the private sector. Table 12 offers a summary of the activities and objectives stipulated in the Aquaculture Policy, the Aquaculture Export Strategy and the Aquaculture Development Plan that provide support to the 4 dimensions of an enabling environment. It is possible to note that these documents cover extensively measures that can be taken by government in support of the first dimension (Data, information and capacity development), but more actions could be taken to develop a more enabling environment in the remaining three areas, in particular in relation to ii) Infrastructure, markets and ICT and iii) Financial environment.

Table 11 Assessment of adaptation challenges, opportunities and NFA's policy and Aquaculture Strategy objectives incidence along the ornamental fish value chain. The objectives of the policy and aquaculture strategy presented for the tilapia value chain (Table 2) are also of relevance to the ornamental industry. Therefore the ones registered on this table are those only specific to ornamental.

	Input suppliers	**Primary producers**	**Local retail**	**Exporters**
Adaptationchallenges	Lack of local stock of brine shrimpLack of new broodstock	Lack of access to creditWater quality Availability of medication for treatment Cost of electricity	Cost of electricity	Ensuring biosecurity standards Lack of steady supply for export
Adaptation opportunities	Promote investment in the production of local feeds Improve broodstock Promote use of renewable technologies and better back-up systems Facilitate the entry of medication and antibiotic fit for purpose Promote specialization and best practices Support R&D for feed and local brine shrimp production Promote development of infrastructure resilient to hurricanes and droughts	Promote use of renewable energy sources and better back-up systems Promote installation of on-site water reservoirs and storage systems Provide consistent technical support to fish farmers Facilitate the entry of medication and antibiotics fit for purpose Capacity building of Veterinary Service Division Promote specialization and best practices Develop financial mechanisms designed for the industry Promote the development of infrastructure resilient to hurricanes and droughts	Use of renewable energy sources and back-up systems Facilitate the entry of medication and antibiotics Improve marketing for export market	Develop further facilities with high standards for international export and shipping (e.g. an export unit) Improve and master packaging technologies and practices Reduce bureaucracy on exporting licenses and permit Promote marketing research
Policy	Increase ornamental and food fish fingerling production,in keeping with the Aquaculture Branch's mandate for enhancing fish production.	Strengthen and build capacity of fish farmersand related producer organizations to effectively participate in the value chain.		
	Encourage the creation of an enabling environment that will facilitate the development and expansion of the ornamental fish industry, with emphasis on the targeting of the export market.			
Aquaculture Development Plan	A thorough study to evaluate the possibilities of producing and selling brood stock and/or juveniles/seeds. Given the right conditions, this can attract different private entrepreneurs to co-finance this initiative.	Start farming new ornamental fish species to be sold locally and abroad.	Design and organize marketing campaigns for domestic sales	Start ornamental fish exports

Table 12. This table summarises key objectives set out in the new Final Draft National Fisheries and Aquaculture Policy (2014) and the Aquaculture Export Strategy (where specified) that support the development of key components of the enabling environment for adaptation in the private sector. P= Policy. ADP= Aquaculture Development Plan. AES: Aquaculture Export Strategy

ENABLING ENVIRONMENT FOR PRIVATE SECTOR ADAPTATION

Data, information and capacity development	SOURCE
Promote research and development and its application to support the aquaculture industry.	Policy
Establish appropriate mechanisms, such as databases and information networks to collect, share and disseminate data related to aquaculture activities.	Policy
Strengthen extension services and training programmes to support the aquaculture sector.	Policy
Promote responsible aquaculture practices for sustainable development of rural communities.	Policy
Promote active participation of aquaculture stakeholders, their communities and environmental organisations in the development of responsible aquaculture management practices.	Policy
Collect, disseminate and exchange timely, accurate and pertinent statistical information on international trade in fish and fishery products through relevant national institutions and international organizations	Policy
Develop capacity of stakeholders in the fisheries sector to incorporate climate change considerations, including disaster risk management in fisheries development and management	Policy
Develop education and training for the entire disaster risk management cycle, especially for climate-related disaster mitigation	Policy
Collaborate with research institutions to fill critical gaps in knowledge to assess the vulnerability of aquatic ecosystems, fisheries and aquaculture to climate change.	Policy
Build public sector / private sector partnerships to better mobilize resources including knowledge.	Policy
Develop and implement climate change and disaster risk management public awareness, education and information programmes targeted to key stakeholders.	Policy
Establish effective, efficient and comprehensive systems for information and data collection (economic, social, biological, etc.) and management, in close collaboration with all stakeholders.	Policy
Develop and establish regulations/protocols/ MOUs with partner institutions and other stakeholders at the national, regional and international levels that address, inter alia, authorization to collect, ownership and use of information and data related to capture fisheries, aquaculture, as well as, aquatic and associated ecosystems.	Policy
Ensure a functional institutional framework and programme for applied fisheries research, in particular statistical and biological data collection, fish stock assessment and aquaculture and programmes of collaboration with non-government institutions.	Policy
Best Management Practices and Product Standards have to be established for the most important fish produced in Jamaica	ADP
Selection of alternative feed suppliers, and negotiations of future supplies	ADP
Solutions have to be researched, including the possible importation or viability of local production for 'super-male' tilapia, which, crossed with any female, will produce only-male fish.	ADP
Nutritional studies should be undertaken, to assess digestibility and other performance indicators in tilapia farming.	ADP
Use of the same strains of to safeguard the uniformity of products to be sold domestically, and in the future, to foreign destinations.	ADP
Studies to select local raw materials for feed production	ADP
Information-sharing, training for staff and other key stakeholders and public education	ADP
Studies on water quality and water renewal practices and strategies should also be pursued, covering a number of situations of interest to local farmers.	ADP

Table 12. (CONT.) This table summarises key objectives set out in the new Final Draft National Fisheries and Aquaculture Policy (2014) and the Aquaculture Export Strategy (where specified) that support the development of key components of the enabling environment for adaptation in the private sector. P= Policy. ADP= Aquaculture Development Plan. AES: Aquaculture Export Strategy (not an NFA document)

ENABLING ENVIRONMENT FOR PRIVATE SECTOR ADAPTATION	
Infrastructure, markets and ICT	**SOURCE**
Implement zoning of lands and water bodies for aquaculture and facilitate the provision of adequate water supply in collaboration with responsible agencies or entities.	Policy
Create an enabling environment, including infrastructural support and marketing intelligence systems, for increased marketing and distribution of locally produced fish and fishery products in the domestic and international markets.	Policy
Strengthen early warning and response capacities at the national and local levels.	Policy
Planning of national survey to characterize Ornamental fish trade	ADP
Start farming new ornamental fish species to be sold locally and abroad	ADP
Chinese firms can bring in technology and new knowledge from their own country to enhance Jamaica aquaculture prospects	ADP
A thorough study to determine best available sites for coastal and offshore mariculture should be undertaken.	ADP
Improvement of the image of tilapia among consumers, by establishing the most desirable presentations for the product	ADP
Market survey, for the US and Canada	ADP
Farm road conditions, drainage canals and water quality improved.	AES
Customised market opportunities, market entry requirements and strategies provided.	AES

Table 12. (CONT.) This table summarises key objectives set out in the new Final Draft National Fisheries and Aquaculture Policy (2014) and the Aquaculture Export Strategy (where specified) that support the development of key components of the enabling environment for adaptation in the private sector. P= Policy. ADP= Aquaculture Development Plan. AES: Aquaculture Export Strategy (not an NFA document)

ENABLING ENVIRONMENT FOR PRIVATE SECTOR ADAPTATION	
Financial environment	**SOURCE**
Implementing cost recovery for services conducted as it relates to assistance provided to aquaculture enterprises, research and development;	Policy
Provide disaster relief mechanisms for aquaculture, recognizing its contribution to the economy and national development.	Policy
Improve the systems for expedient rebuilding and rehabilitation of the fisheries and aquaculture sector in the aftermath of natural disasters.	Policy
Support development of innovative insurance products by the private sector that is relevant and affordable to fishers and fish farmers, especially those who operate on a small scale	Policy
Improve the sources of funding for the national Fisheries Authority by obtaining permission from the GOJ to use income from services (for e.g. registration and licensing) to be used for the financing of activities and programmes.	Policy
Conduct an analysis of the revenue base with a view of introducing measures to increase revenues from the fisheries sector, including: - Cost recovery and cost sharing through increased user fees for the services provided by the national Fisheries Authority; - Levy on imported and exported fish and fish products; and - Economic rent from fisheries by establishing, inter alia, realistic licensing fees.	Policy
Determine the appropriate modality for financing various services provided to the industry, e.g. cost recovery (e.g. fisheries management), cost sharing (e.g. artisanal fisheries inputs) and subsidies (e.g. training, research and development).	Policy
Affordable and accessible finance made available	AES
A thorough study to evaluate the possibilities of producing and selling brood stock and/or juveniles/seeds. Given the right conditions, this can attract different private entrepreneurs to co-finance this initiative.	AES

Table 12. (CONT.) This table summarises key objectives set out in the new Final Draft National Fisheries and Aquaculture Policy (2014) and the Aquaculture Export Strategy (where specified) that support the development of key components of the enabling environment for adaptation in the private sector. P= Policy. ADP= Aquaculture Development Plan. AES: Aquaculture Export Strategy (not an NFA document)

ENABLING ENVIRONMENT FOR PRIVATE SECTOR ADAPTATION	
Policies and institutions	**SOURCE**
Facilitate access to land and coastal areas suitable for aquaculture at nominal rentals and introduction of legislation for protection of aquaculture investments.	Policy
Extend to aquaculture the policy of the Ministry of Agriculture of reduced taxation on lands for agriculture (D rating on farm lands).	Policy
Facilitate appropriate consultation with, and participation of industry, as well as environmental and consumer groups in the development and implementation of laws and regulations related to trade in fish and fishery products.	Policy
	Policy
Improve governance arrangements by identifying and facilitating the empowerment and participation of the relevant interest groups (particularly vulnerable groups in coastal areas).	Policy
Strengthen existing mechanisms that promote integrated multi-sectorial approaches to governance and management.	Policy
Formal arrangements such as MOUs will be initiated to ensure stakeholder, including, fishers and fish farmers participation in the governance process.	Policy
Develop import regulatory mechanism that (i) restricts poor quality product that damages the perception and purchase of products and (ii) does not put the industry at risk with under-pricing. The desired response is an import policy that covers sanitation requirements of inputs, processing and the time to market (for example days from production).	ADP
Implementation of traceability programs, certification of water quality and/or of environmental impacts, managerial and logistic aspects.	ADP
Standardization of production, and to make sure that only good quality fish enters the market, a 'Quality Seal' should be used by producers attaining the required standards	ADP
Creation and definition of the characteristics and operational strategies of a 'clearing house' , that will receive standardized fish production from farmers, keep them under one roof, and under a centralized sales and distribution system, serve demand of US and Canadian buyers, and afterwards, that from other origins as well.	ADP
Intervention by local authorities, associated with private industry or on their own, to finance hatchery production in support of a more diversified aquaculture activity	ADP

8. RECOMMENDATIONS

8.1 Mainstreaming climate change considerations into aquaculture management plans and in support of the implementation of the Fisheries' bill

In accordance to Section 13 , paragraph 3 (p.20) of the Fisheries' bill: "The Authority shall prepare and keep under review aquaculture management plans." Accordingly, climate vulnerability and risk analyses can inform the development of the aquaculture management plan by:

- Identifying the applicable aquaculture management area
- In specifying the objectives to be achieved and the strategies to be adopted
- In specifying conditions to be applied to licenses
- In identifying any possible environmental effects on the operation of anaquaculture activity
- In specifying the statistical and other data required to be given or reported

Additionally, (Art. 13.3) the "Authority shall take such steps as are necessary to ensure that sufficient information is available concerning the aquaculture activity that is subject to the aquaculture management plan. Take into consideration the best scientific information available regarding an aquaculture activity".

This review finds that the Aquaculture Division could develop a series of operational manuals that could support the application, approval and implementation process for new aquaculture ventures, and which should incorporate climate change considerations. In particular, the following manuals could be developed:

- Manual on how to write a management plan for an aquaculturefacility license application
- Manual on the design principles for climate smart aquaculturefarms
- Manual on pre- and post-harvest best practices in aquaculture.

In the case of the development of a manual on the design principles for climate smart aquaculture farms, the Aquaculture Division can draw on the guidelines provided by FAO (2013), where key requirements to make aquaculture operations climate-smart include:

- improving efficiency in the use of natural resources to produce fish and aquatic foods;
- maintaining the resilience aquatic systems and the communities that rely on them to allow the sector to continue contributing to sustainabledevelopment; and
- gaining an understanding of the ways to reduce effectively the vulnerability of those most likely to be negatively impacted by climatechange.

Accordingly, FAO notes that "Examples of win-win tactics for attaining CSA objectives that are available to the sector include:

- increased production efficiency through better integrated systems;
- improved feeding and reduced losses from disease in aquaculture;
- the reduction of postharvest and production losses; and
- the further development of regional trade"

In addition to the development of guiding design and operational manuals, it is hereadvised to develop a policy brief on aquaculture and climate change for members ofthe National Fisheries Board. This guide should include basic information on climatechange trends in Jamaica and on the potential impacts and climate adaptation options for aquaculture.

8.2 Facilitating access to finance for the acquisition of climate smart infrastructure and equipment

As noted in Section 7 of this report, there are a number of measures that aquaculture value chain actors can implement in order to reduce their sensitivity and exposure to climate hazards. Many times, these measures offer win-win solutions that can also help to increase the productivity and reduce the variable costs of value chain operations, such as the acquisition and use of renewable technologies. In other instances, measures can help to reduce exposure to transboundary climate risks, for example through the development of local input substitutes (such as feed).

The implementation of adaptation measures to increase climate resilience in the aquaculture sector requires, nonetheless, the development of a financial plan that can support investment decisions. This study finds that the Division should explore how to further access climate finance in order to support adaptation activities within the aquaculture sector.

While it is beyond the scope of this assignment to provide detailed guidance to the Division on how to access financial resources to support the development and implementation of climate adaptation activities in aquaculture, this study recommends that the division starts by getting more acquainted with the climate finance landscape in the country (see Figure 8 below). The National Framework to respond to climate change, outlined in the Green Climate Fund country programme for Jamaica,[4] is a good resource for the Division to get familiar with key information on institutional arrangements, on the roles and contributions of key stakeholders and on the country priorities to the GCF, all of which are critical elements of the country's climate change agenda.

[4] The GCF country programme for Jamaica can be accessed at: https://www.greenclimate.fund/sites/default/files/document/country-programme-jamaica.pdf

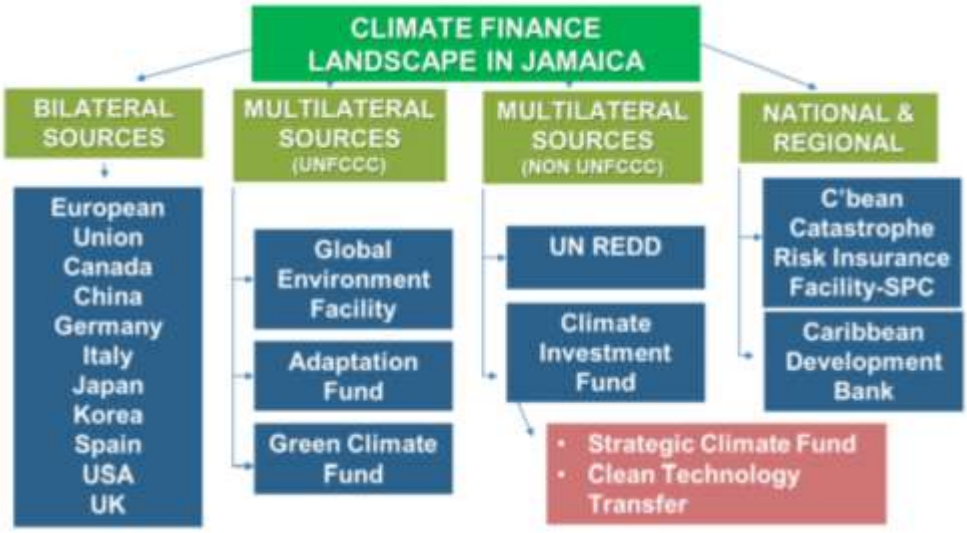

Figure 8 Climate Finance Landscape of Jamaica. Source: Climate Change Division (2017) in GCF Country Programme available at: https://www.greenclimate.fund/sites/default/files/document/country-programme-jamaica.pdf

As noted in the Country Programme, a series of local products and projects are currently being used in Jamaica to encourage private sector engagement in climate change and could be further explored in the context of adaptation in aquaculture. Table 12 below describes some of the instruments available to the private sector for the access to finance for climate adaptation.

Table 12 Climate Related products and services

Company name	Dedicated loan products and projects
GK Insurance (in partnership in the with Germany)	This scheme develops a climate adaptation insurance initiative
Jamaica Co-operative Credit Union League and the National knowledge Union of Co-operative Societies	Credit for climate smart investments, relief subsidies and technical
World Bank and Inter-American, Development Bank (IDB), Development Bank of Jamaica	These multilateral entities offer climate smart and green loans through
Scotiabank	SME Energy loan program
Jamaica Business Development	Grant financing for technical assistance to MSMEs Corporation
JN Small Business Loan	The Water Project provides financing for developers to install water conservation devices and measures in the houses that they construct

It is here recommended that the Aquaculture Division should liaise with the Climate Change Division and PIOJ in order to identify sources of climate finance and to develop additional services for the sector (e.g. early warning systems and climate insurance).

8.3 Strengthening strategy for training and capacity building

The National Fisheries and Aquaculture Policy recognises the need to strengthen extension services and training programmes to support the aquaculture sector. Inorder to build the capacity of relevant stakeholders and allow partners to participate in the governance process, new skills and career paths will have to be developed.

Training and capacity building programs should be grounded on the best availablescience and can be co-designed and delivered through partnerships with universities, labs and accelerators, private firms and NGOs. Adequate training is critical in order to sustain the industry.

Training programs integrating climate change considerations should be developed for:

- The Chef Executive Officer
- Fishery inspector (who also undertake educational and scientific research; survey operations to inspect or conduct investigations); and observers: scientific and monitoring functions

Training programs should also be developed for the legal and administrative staff on to support the development, approval and Implementation of aquaculture ventures, including training on:

- Licensing processes
- Control, surveillance and enforcement
- Environmental Impact Assessments
- Data analytics

Training programs should be developed to support fish farm services and product development on:

- Aquaculture technology and biology
- Production systems and culture technologies
- Nature-based Solutions
- Climate impacts on the aquatic environment
- Monitoring and evaluation
- Value chain resilience

Additionally, the National Fisheries and Aquaculture policy states that

"The development of the ability of the Fishing Cooperatives to provide commercial services to fishermen, as well as to serve as facilitators in theprocess of upgrading, will require a significant effort to increase the capacities of these organizations. Measures will be introduced to improve the organizational capacity of NGOs involved with artisanal fishers and fish farmers, to enable them to spearhead programmes for upgrading of artisanal fisheries and aquaculture and where appropriate,facilitate their transition into industrial fisheries."(p.xvi)

This review finds that greater focus should be granted to developing the capacity of fish farmer associations to provide services to tilapia and ornamental fish value chain actors. As it will be indicated in the following section, the Aquaculture Division could explore the development of new forms of collaborations and the establishment of Memorandums of Understanding (MOUs) with organisations that can support the development and delivery of training and capacity building programs. In this respect, the review finds that the Policy places greater attention to the development of co-management and collaborative arrangements for the capture fisheries than to aquaculture (National Fisheries and Aquaculture Policy, p. xvi), andthus there is room to further strengthen the co-management and MOUs directive for the aquaculture Industry.

8.4 Strengthening partnerships and collaboration

This review finds that there are key actions that the Division can take in order to support the development of services for aquaculture. In particular, the development of strategic partnerships with academic institutions, NGOs and the private sector can help ensure the delivery of services and products required by the industry.

As noted In the National Fisheries and Aquaculture policy (p.45):
" Formal arrangements such as MOUs, will be initiated to ensure stakeholder, including, fishers and fish farmers participation in the governance process."

The development of strong partnerships is also critical in order to build social capital within the value chains and to strengthen collaboration and joint problem solving. Through collaboration and joint problem solving, value chains can become more flexible and agile, which are critical components of adaptive capacity and climate resilience. It can also help with unlocking access to key resources such as information and to Improve data and knowledge sharing across value chain actors.

During the facilitated ornamental stakeholder workshop, participants acknowledged the need to build strong partnerships. Some recommended the development of a “breeders hub”, as well as alliances between breeders to escalate concerns to government, whilst others

believed it is important to consolidate partnerships with the Veterinary Division, Feed suppliers and customs in order to set an agenda forward. Tilapia fish farmers suggested there is a need to liaise with academic and education institutions (such as CASE, UTECH, UWI) to support the improvement of breeding practices, quality of broodstock, uptake of adaptive technologies for local feed production and best management practices. Fish farmers suggested they could discuss with these institutions what they could do in terms of research in their own farms. Farmers understood that their ability to discuss with potential new buyers (e.g. Grace Kennedy) depends on their ability to first organise internally in order to be able to demonstrate reliable supply of raw tilapia to interested processors.

In addition to the suggestions provided by value chain actors, this study finds that particular attention could be granted to the development of partnerships to ensure a more effective use of water resources. As noted in Section 5 of this report, Jamaica is highly exposed to increased temperatures and prolonged droughts. Currently, earthen ponds predominate in Jamaica due to the relatively lower construction and maintenance costs, with at least 50% of these ponds being supplied by irrigation schemes. Higher temperatures and drought pose a challenge to the provision of water supplies to tilapiaaquaculture and reduced water levels in ponds can affect fish growth and health.

Several options could be explored for inter-agency collaboration in support of better water harvesting and management practices. One interesting opportunity that the Aquaculture Division could explore is the development of water funds and equitable water provision schemes in areas of high tilapia production (e.g. Hill Run). As noted by The Nature Conservancy "Water funds allow freshwater users, including communities, small businesses and broader industries, to invest in the conservation of water sources, which generates sustainable, long-term funding for the protection and restoration of lands and forests surrounding these sources." (p3).3 Accordingly, water funds can be not only a successful instrument to improve water management in times of drought, but can also help build value chain resilience through the development of natural infrastructure and natural capital that can reduce the risk of flooding at fish farms and adjacent road grids and thus reduce the risk of supply chain disruptions between fish farms and markets.

Areas where partnerships and MOU development could be sought and the organisations that government could partner with on each topic are here summarised in Table 13 below.

Table 13 Summary of key thematic areas where partnerships and MOUs can be sought by the Fisheries Division in support of the development of services and products to the aquaculture industry

Thematic area of collaboration	Key organisations to foster partnerships to lead/support on each theme
Biosecurity and fish health	Tilapia: Veterinary Service Division Ornamental: Veterinary Service Division
Packaging standards and quarantine procedures	Ornamental: The Competitiveness Company, RESET Academy
R&D on fish feeds	Tilapia: Jamaican Broilers (Hi-pro), UTECH, CASE (College of Agriculture, Scienceand Education), Scientific and Research council Ornamental: Scientific and Research council
R&D on packaging and markets	Tilapia: Ministry of Tourism
Awareness raising on climate change and disaster risk management	University of the West Indies (Climate studies group) Meteorological Service of Jamaica
Extension and training services to fish farmers on best practices	HEART-NTA CASE (College of Agriculture, Science and Education)RESET Academy Fish farmers with benchmark practices
Import - export enabling conditions	JAMPRO JAM trading boardCustoms
Finance and funding	Social Development CommissionAgro-investment corporation Development Bank of Jamaica Jamaican Social Investment Fund Micro Investment Development Agency (MIDA)Exim bank IDB PIOJ (Adaptation Fund)[5]
Water management	National Irrigation CommissionWater Resource Authority The Nature ConservancyFish farmers association Jamaican National Foundation Water project (for urban ornamental within Kingston area)
Nature based Solutions	The Nature Conservancy National Irrigation CommissionFish farmers association
Monitoring, Control and Surveillance	CASE Universities Competitiveness CompanyFish farmers association
Databases and information networks to collect, share and disseminate data related to aquaculture activities	CRMFAO Fish farmers association Universities

[5] PIOJ is the National Implementing Entity (NIE) of the Adaptation Fund. For more information, visit: https://www.adaptation-fund.org/ie/planning-institute-of-jamaica/

8.5 Providing continuity to this assignment

Despite its short duration, this assignment has successfully engaged a significant number of value chain actors within the tilapia and ornamental fish value chains. It has casted interest among workshop participants on what they should do in order to better prepare to a changing climate and generated key insights to foster further collaboration among the stakeholders.

In order to provide adequate continuity to the outputs generated in this assignment, the Aquaculture Division should ensure that the findings and recommendations presented in this report are integrated into the new development plan for aquaculture. Furthermore, the Division should facilitate the development of geographical clusters and/or thematic working groups to consolidate the relationship between actors that have been engaged through this assignment.

Finally, it is highly recommended for the Aquaculture Division to take the role or facilitator in partnership development between value chain actors, and that it promotes the integration of new entities into the value chain network to strengthen R&D programs for the sector and to improve the provision of training and extension services to the sector.

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10. ANNEX 1 Attendance list to stakeholder workshops

TILAPIA	
Name	**Attendence**
Dwyane Jones	Virtual
Niconor Reece	Virtual
Stephen McLish	Virtual
Clive Williams	Virtual
Winsome Gordon	Virtual
Marlene Tulloc	Virtual
Kenisha Morgan	Virtual
Howard Young	Virtual
Jones H	Virtual
Yvette Haughton	Virtual
Everald Smeikle	Virtual
Jermaine mcfarlane	Virtual
Ingrid Parchment	Virtual
Gilbert Kong	Virtual
Vincent Wright	Virtual
Paul Bynbloss	Virtual
Gavin Bellamy	Virtual
Frederick Lyn/Marcia Lyn	Virtual
Patrick Golding	In Person
Melisha Meeks	In Person
Selena Ledgister	In Person
Lerrone Failong	In Person
Sherieka Benjamin	In Person
Recardo Lorraine	In Person
Ornella Rose	In Person
Leanne Bennet	In Person
Nadia McNesh	In Person
Rodish Hines	In Person
Fu Chang Liiv	In Person

ORNAMENTAL	
Name	**Attendence**
Aldin Gassop	In Person
Alolith Gassop	In Person
Averly Smikle	In Person
Christopher Stephenson	In Person
Derrick Deslandes	In Person
Dwayne Marsh	In Person
Dwyane Jones	In Person
Hendel Edwards	In Person
Jermaine McFarlane	In Person
Kerrere Fairclough	In Person
Milton Nisbeth	In Person
Melissa Meeks	In Person
Nadia McNesh	In Person
Bley Fille	In Person
Patrick Golding	In Person
Phillip Lee	In Person
Selena Ledgister	In Person
Sley Fylle	In Person
Wilton Nesbeth	In Person
Clive Williams	Virtual
Damian Benjamin	Virtual
Debbie Holding	Virtual
Everton Reece	Virtual
Gary Ferguson	Virtual
Gregory Kong	Virtual
Kamar Russell	Virtual
Kenisha Morgan	Virtual
Marlene Tulloc	Virtual
Omar Frankson	Virtual
Orville Brown	Virtual
Patrick Mignott	Virtual
Paul Byblos	Virtual
Phillip Lee	Virtual
Robin Hall	Virtual
Runique Edwards	Virtual
Sandra Johnson	Virtual
Sophia Peart	Virtual
Vincent Wright	Virtual
Winston Folkes	Virtual