Centre for Environment Fisheries & Aquaculture Science

Cefas

Consultancy to strengthen the policy and regulatory framework for climate resilient fisheries and aquaculture management in Jamaica (C8154)

Deliverable D7- Final report

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Contents

1. Executive summary

This document summarises the assignment undertaken by Cefas and MRAG team over the last ten months. The work conducted an up-to-date review of documents, reports, websites, and online workshops. These activities were conducted in collaboration with NFA colleagues. The intention was to capture and document the current understanding on the effects from: i) climate change on fisheries and ii) climate change on aquaculture. This final report covers the literature review with details on the current knowledge in Jamaica across these themes. The report also includes existing gaps (with a dedicated gap analysis), and future recommendations to support filling some of these gaps. The later section of this report contains the current understanding on institutional capacity, a table with a framework strategy (e.g. with key topics, phases, and outcomes) and road map (with phases I, II and III covering from the present date to + 5 years). This information will help to strengthen the existing and new policies to advance fisheries, aquaculture, and climate change developments. This work has been developed in collaboration with the National Fisheries Authority (NFA hereafter) and their relevant advisors in Jamaica to ensure it advances their current work, legislation, and ambition to support a climate smart approach to fisheries and aquaculture.

This final report is a compilation of the whole suite of deliverables:

- D1-Inception report with approach and methodology.
- D2-Draft literature review, consultation report including: the assessment of the climate change impacts on the sector, gap analysis and the analysis of the institutional framework of the National Fisheries Authority.
- D3-Consultation Report and Final Literature Review and first draft of the Strategy and Action Plan for National Fisheries and Aquaculture Policy.
- D4- Second Draft of strategy and action plan based on comments from consultations and technical team.
- D5-Final draft of strategy and action plan based on feedback from the consultation reports, validation workshop and technical team with some results from the consultation exercises.
- D6-Review the national biosecurity policies and practices in Jamaica for aquatic animal health of both farmed and wild populations, their basis in legislation, and the capacity of Government to implement aquatic animal biosecurity to international standards, and, where required, make recommendations for investment to improve aquatic animal biosecurity, which are aligned with climate smart strategies.

It is important to emphasise that throughout, the work was prepared and presented to the NFA and their consultants during a series of 3 online workshops (all transcripts and slides were shared with all participants). The results from these online discussions strengthened and added further insights to the work, sharing specific views on current activities, stakeholders, and current and future opportunities to support this overall assignment.

Overall, the work from outputs D1-6 helped to produce proposals for dedicated actions and a road map to support the development of the first Strategy and Action Plan for National Fisheries and Aquaculture Policy. This work has also encouraged further dialogue and consultation in Jamaica with relevant stakeholders.

2. Overview of this work

This work was composed of several phases, these were i) a literature review for fisheries & climate as well as aquaculture & climate. The results from the synthesis were also presented and discussed over online workshops with the NFA colleagues to ensure the review captured the current state of play. At the time of writing this document, all relevant documents were included in this report. The list of files provided by the NFA is summarised in the sections below:

2.1. Jamaica Fisheries Evidence Review

Fisheries relevant documents

1. **The Jamaica Fishing Industry: Brief Notes on its Structure, Socio-economic Importance and some Critical Management Issues,** G. Andre Kong, Ministry of Agriculture [no date]. (file name “Fisheries paper GAK”)
2. **The Draft document of the National Fisheries and Aquaculture Policy**, Ministry of Agriculture and Fisheries, 2014.
3. **Jamaica National Marine Fisheries Atlas,** CARICOM Fisheries Unit, 2000. (file name “JAM_NMFA”)
4. **Fish production 2010-2019,** [no author] [no date] (file name: Fish Production 2010-2019_averaged)
5. **Conch Estimates of Abundance and Potential Yield for The Queen Conch Population on the Pedro Bank, Jamaica – 2021 Conch Survey,** Jamaica National Fishery Authority, December 2021.
6. **Jamaica’s Non-detrimental findings for Queen Conch (*Strombus gigas*),** Jamaica National Fishery Authority, 2021.
7. **Queen Conch Fishery Management Plan,** Jamaica National Environment and Planning Agency, August 2016.

Other documents

8. **Update of Nationally Determined Contribution (NDC) of Jamaica to the UNFCCC,** [no author] 2020.
9. **Intended Nationally Determined Contribution of Jamaica to the UNFCCC** [no author] [no date].
10. **Third National Communication of Jamaica to the UNFCCC,** Ministry of Economic Growth and Job Creation, 2018.
11. **The State of the Jamaican Climate 2019,** University of the West Indies (for the Planning Institute Jamaica), 2021.
12. **The State of the Jamaican Climate 2015,** University of the West Indies (for the Planning Institute Jamaica), 2017.
13. **The State of the Jamaican Climate 2012,** University of the West Indies (for the Planning Institute Jamaica), 2012.
14. **Vision 2030 Jamaica: National Development Plan**, Planning Institute of Jamaica, 2009.
15. **Medium Term Socio-economic Policy Framework 2009 – 2012,** Planning Institute of Jamaica, 2009. (file name "MTFFinalWeb2")
16. **Medium Term Socio-economic Policy Framework 2015 – 2018,** Planning Institute of Jamaica, 2015. (file name "MTF-2015-2018-final-1")
17. **Medium Term Socio-economic Policy Framework 2018 – 2021,** Planning Institute of Jamaica, 2018. (file name "MTF-2018-2021-March-2019-2-1")
18. **Biennial Update Report of Jamaica,** Ministry of Economic Growth and Job Creation [no date].
19. In addition, the NFA team during the workshop exchanges also shared the Mariculture policy and Beach policy documents at a later stage for the team to read and incorporate as part of this exercise. These documents provided further insights on likely areas, species, and geographic extent where future sectors could be further developed or integrated.

This section provides a synthesis and analysis of the documents provided for review by the NFA. These documents are a subset of those provided by MOAF which were selected for their potential relevance to Jamaican fisheries. This document will detail what the documents contain (the synthesis) and determine their relevance and significance to characterising Jamaican fisheries (the analysis). Following this, findings from both sections will then inform a series of recommendations in how best to characterise Jamaican fisheries.

2.1.1. Fisheries-relevant documents

Synthesis

Seven files were determined to be directly relevant to Jamaican fisheries from those provided for review. These comprised:

1. written opinion by a ministerial Director;
2. national policy/legislation;
3. consolidated fisheries evidence output;
4. raw fisheries market data;
5. There were single species stock assessment files;
6. species-specific management plan.

All such files are considered directly relevant to Jamaican fisheries as they primarily seek to characterise the status of fisheries in Jamaica, compared to the climate change relevant documents and other files which are primarily focussed on non-fisheries aspects, but may provide indirect or supplementary information relevant to Jamaican fisheries.

The files provide some high-level description of the composition of Jamaican fisheries. File 1 presents the opinions and arguments of the ministerial Director for Fisheries about the state of Jamaican fisheries. It begins with a description of the different components of the fisheries (dynamics, gear used) then moves on to detail the importance of the fishing sector to the economy and to employment in Jamaica. This file (and file 2) detail(s) that – other than that for conch (*Strombus gigas* [now *Aliger gigas*]) and spiny lobster (*Panulirus argus*) – all fisheries operate on an open-access basis.

File 3 provides a high-level description of the composition of Jamaican fisheries. It gives an indication of the species of the highest value and those with the greatest associated landings, such as Queen conch (*A. gigas*) and reef finfish, such as Hogfish (*Lachnolaimus maximus*) and Groupers *Myctoperca spp.* Files 5 and 6 (e.g individual stock assessments) corroborate and expand on the detail for Queen conch (*A. gigas*), identifying the area responsible for 90% of conch landings (from Pedro Bank). Information concerning the fisheries dynamics, such as the large artisanal fishery and the commonly used gear types (Z Antillean fish trap, nets/seines and various low-intensity gear like spearguns) was also available in these files. The fishing sector is a reportedly important part of the Jamaican economy and at one time supported up to 20,000 individual fishers.

File 4 provides further evidence concerning the relative importance of each fishing sector through landings data for 2010 - 2019. The data show the artisanal fishery to comprise the most landings by weight in tonnes (91 – 98%). Further data on conch (up to 5%) and lobster (up to 3%) are also presented in this report. Landings of shrimp and “other” (presumed herein to comprise a variety of species such as sea cucumber and other non-artisanal fish) were either nil or <1% of total landings by weight in all years except for 2010, where more shrimp were landed than spiny lobster (2.3 compared to 1.6%). This file

then uses fixed market prices (as of 2001) for each fishery group to estimate the value of these landings in USD. The prices show conch, lobster, and shrimp to constitute the most valuable commercial species, all being at least double the value of artisanal fish. This appears consistent with other Caribbean fisheries.

Files 5 and 6 give some characterisation of the status of the Queen conch (*A. gigas*) fishery, stating that conch densities have remained above 100 individuals per hectare (/ha) since 1994, and contextualises these data with references to Jamaica generally exhibiting some of the highest densities and abundances of Queen conch in the Caribbean. The 3-year interval fishery surveys indicate conch density to range from 99 – 330 individuals/ha. File 6 then argues that Jamaican Queen Conch is relatively stable and identifies the key threats to its status as including illegal fishing and localised overexploitation. The findings of files 5 and 6 are in line with the management plan and evidence strategies detailed in file 7 – the Queen Conch management plan.

With regards to illegal, unreported, and unregulated (IUU) fishing, fisheries in the Caribbean function as a social security net. IUU fishing therefore results in activities such as seafood fraud, leading to economic loss. IUU often involves a transnational crime. One major challenge for SIDS therefore is the large ocean space for which they have responsibility. Therefore, countries like Jamaica need to develop countermeasures against IUU fishing. The drivers of IUU include profitability, low risk and the fact that penalties are relatively low. What is needed is regional cooperation facilitated by policies such as the Caribbean Countries Common Fisheries Policy supported by the CRFM. There is also need for training courses on IUU matters. Cooperation on combatting IUU fishing should include the closing off markets for IUU fishing and strengthening the regulatory framework.

File 2 provides further detail on the legislation and policies referred to in file 3, such as the open access arrangements for most fisheries. This file also gives further detail on fisheries management measures, such as restrictions of the landings of berried or under-sized lobsters; a common measure implemented throughout the Caribbean. Greater detail is provided regarding management measures for conch, likely due to compliance with the Convention for the International Trade of Endangered Species (CITES), whereby stricter measures such as individual quotas, a total allowable catch and closed seasons are enforced. Additional reference is also provided to characterise the sport fishery in Jamaican waters, pointing to typical sport-importance species, for example tuna, kingfish, and marlin – note that this was taken directly from file 1 and referenced.

File 2 then goes on to detail the key challenges to Jamaican fisheries, notably the overexploited status of many of its commercial species. Various factors are pointed to in attributing this status, such as the taking of immature fish, theft, presence of abandoned, lost, or otherwise discarded fishing gear (ALDFG, “ghost gear”) and destructive fishing practices. Non-fishery specific pressures are also referenced, such as storm events, pollution, non-native/invasive species, and disease impacting ecosystem engineering species, such as sea urchin. File 2 then finishes by detailing the proposed marine

management of Jamaican fisheries, notably the zonal management programme, with many individual points of policy, implementation, and enforcement to maintain fishery sustainability.

2.1.2. Limitations and Analysis

The resources examined were extremely useful documents, however, they suffer some limitations, which either constrain the confidence that can be ascribed to them or are dated. The most useful of the files presented – the Jamaican Fishery Atlas (file 3) – was published over 20 years ago. Local, regional, and broader scale changes over this time could have led to meaningful changes within Jamaican fisheries. This key knowledge gap can be somewhat overcome by the availability of landings data as presented in file 4, which show that the artisanal fin fishery maintains its leading position within Jamaican fisheries. However, these data on their own provide minimal indication as to the current state of Jamaican fisheries. If fishing effort were to have increased over time whilst landings remain consistent (which, over the 2010-2019 period, they seem to have), it can be determined that the relative fish stocks are declining, or in poor health. Effort indicators, such as days fished, would be a useful metric to primarily determine whether this trend is apparent.

An additional important point to consider is the lack of evidence within the files to characterise the ecological status of commercial fish stocks and their associated habitats and biotic interactions. There exists some literature detailing the effects of specific pressures on Jamaican reef fish (Hawkins *et al.* 2007; Bruckner *et al.* 2014; Alexander *et al.* 2018), however, there appears to be no consolidation of this evidence to provide a clearer understanding of the available knowledge. Large-scale pressures, such as climate change and regional pollution are, particularly the former, referenced to some extent in the files provided in relation to fish and fisheries. But without an understanding of the likely status of fish and fisheries to such pressures, it is difficult to predict the future status of fish communities, and thereby the future sustainability of Jamaican fisheries. Lower-level pressures such as overfishing, bycatch and local human impacts may also be affecting Jamaican fish communities and fisheries, however, evidence to characterise such pressures are limited (Valentine and Heck, 2005; Ennis and Aiken, 2014). These limitations are less evident for Queen Conch, which benefits from the information in files 5, 6 and 7, however, greater evidence around environmental factors could strengthen any assessment of its status. Characterising any impacts on or changes to the conch's habitat, important biotic interactions, and environmental quality – e.g., pollution, climate change, would provide a more robust model on which to base any predictions as to conch's likely future status. Some dedicated work on conch and lobster's potential vulnerabilities to climate change (including ocean acidification) and likely repercussions for fisheries has started in Belize (Lincoln et al., 2022). There is a likelihood that other stressors could also be adding pressure on these stocks (e.g. pollution and microplastics), further research could elucidate some of these wider changes.

Whilst evidence to characterise Jamaican fish communities is severely lacking, there is a better knowledge base for Jamaica's most biodiverse ecosystem – coral reefs. Various global and regional programmes and initiatives have focused on the health and status of coral reefs, from broadscale reviews (Mumby *et al.* 2007; Burke *et al.* 2011) to lower-level studies of specifically Jamaica's coral reefs (Hardt, 2009; Côté *et al.* 2013), which generally indicate a variable and unclear history. Coral reefs play a critical role in tropical marine foodwebs, which includes many commercially important fish species. As such, a greater understanding of fish and fishery dynamics associated with Jamaican coral reefs would be highly beneficial, as these provide essential habitats (e.g. feeding, nursery and overall habitats for species) and therefore would be of benefit to document. Evidence for other habitats, such as sandy benthic would similarly prove useful, however, given the diversity of species within coral reefs, and the map of fishing activity provided in file 3, fishery evidence associated with coral reefs would be much more useful.

The fixed prices used in file 3 provide some indication as to the economic importance of fishing in Jamaica. However, fixed prices naturally are very limited in the accuracy of information they can provide and can very easily under- or over-estimate the value of commercial species. It is highly likely that the value for each species may have increased since the prices were determined in 2001, purely due to global inflation. However, it is perhaps just as important to determine the relative value of the fishing sector (to the national economy) as it is to determine the sale prices for fish species. Focussing solely on the latter ignores increases in costs and/or burdens throughout the supply chain, and hence, even if prices for Jamaican species have increased, it may be the case that their value has decreased in real terms.

File 1, provides a coherent overview of the Jamaican fishing sector, but critically suffers from a total lack of referencing or supporting evidence. In isolation, this would not be an issue, as the document is not a scientific report or publication, however, it is referenced multiple times in file 2 – the national fisheries and aquaculture policy. A key issue here is that file 1 is not dated, and is referenced as "Kong, undated". At best, file 1 can be considered anecdotal evidence, and, without being dated, it is impossible to know how relevant the information presented is to characterise the present status of the Jamaican fishing sector. Where file 1 is referenced, it would be preferable to utilise other resources, such as, for example, sport fishing licences and fisher logbooks and/or communications, and reference these directly. As file 2 currently stands, it is consistent in how evidence-based it can be considered.

2.2. Summary of recommendations

A relevant summary of recommendations for Jamaican authorities. These suggestions could be implemented and managed directly, or subcontracted to other organisations, e.g., private tender, CARICOM) are outlined below for consideration:

Recommendations
1. Conduct a literature review based on a systematic approach of evidence to characterise Jamaican fisheries and their associated habitats and biotic interactions.
2. Update the Jamaican National Fisheries Atlas (file 3).
3. Consult on the expansion of fisheries data collection (e.g., fisher effort and attitudes including compliance).
4. Explore the potential for the installation of vessel monitoring systems (VMS) or automated monitoring systems (AMS) to collect more accurate data as to heavily fished areas.
5. Engage with fishers and wholesalers to determine the level of price fluctuation over time.
6. Re-draft the national fisheries and aquaculture policy to either reference formal publications or directly reference available data, e.g. licensing data.
7. Determine what are the current challenges for commercial species under the current and future changing conditions (e.g. conch and lobster).
8. Assess the effectiveness of existing and proposed management measures, including the various protected areas, in so far as, they provide tangible fishery and/or ecosystem benefits, e.g., are there strict human activity controls for these areas? Are they well-enforced?

2.3. Jamaica Fisheries and Climate related relevant documents

Documents reviewed:

1. Third National Communication of Jamaica to the United Nations Framework Convention on Climate Change

2. Plan for Aquaculture Development in Jamaica, 2012 - 2025
3. Climate Change Policy Framework for Jamaica, 2021
4. Government of Jamaica, Ministry of Economic Growth and Job Creation, Biennial Update Report of Jamaica
5. Jamaica, National Marine Fisheries Atlas
6. Climate Change Policy Framework for Jamaica, 2015
7. Intended Nationally Determined Contribution of Jamaica Communicated to the UNFCCC
8. Vision 2030 Jamaica – National development plan: medium term socio-economic policy framework 2015-2018
9. Vision 2030 Jamaica – National development plan: medium term socio-economic policy framework 2018 – 2021
10. Jamaica medium term socio-economic policy framework 2009-2012
11. National Fisheries and Aquaculture Policy, 2014
12. State of the Jamaican climate 2012: information for resilience building: information for Policymakers
13. The State of the Jamaican Climate 2015
14. The State of the Jamaican Climate 2019
15. Update of Nationally Determined Contribution (NDC) of Jamaica to the United Nations Framework Convention on Climate Change (UNFCCC), 2020
16. Vision 2030 Jamaica – National development plan: medium term socio-economic policy framework 2012 – 2015
17. Vision 2030 Jamaica: national development plan, 2009
18. Climate Change Impacts and Adaptation for Coastal Transport Infrastructure in Caribbean SIDS - Climate Change Policy Framework for Jamaica: Jamaica's NDCs Under the Paris Agreement (presentation)
19. Project Report: Consultancy to Identify Sub-Projects on Climate-Resilient Freshwater Aquaculture, Coastal Mariculture/Polyculture, and Other Alternative Livelihoods
20. Government of Jamaica, Ministry of Agriculture & Fisheries, Business Plan 2014 – 2017
21. Government of Jamaica, Ministry of Industry, Commerce, Agriculture & Fisheries, Strategic Business Plan 2019/20 – 2022/23

The section below is a synthesis of the documents provided to Cefas by the Ministry of Agriculture and Fisheries of the Government of Jamaica. This review considered pre-selected documents with relevance for climate-related issues and its consequences to Jamaican fisheries. This text below contains a synthesis and analysis to inform recommendations for the Jamaican fisheries.

2.4. Summary

Jamaica is a Caribbean Island with a population of 2.7 million and a coastline of 1,022km. Its marine environment is an intrinsic aspect of the Jamaican culture, livelihoods, and food provision. It is also important for marine and maritime activities, which account for approximately 90% of the country's $14 billion GDP generated within its coastal zone.

However, climate change is affecting Jamaican fisheries and aquaculture through changes to species distributions, fish habitats, growth, and reproduction, with the increasingly frequent storms and hurricanes directly impacting Jamaican fishing activities by damaging habitats, aquaculture, and fisheries facilities, with safety concerns of fishers at sea.

The set of documents made available provide a good overview of the climate change framework in Jamaica. This includes high-level direction to set the landscape work to allow assessing vulnerabilities to climate change impacts especially along coastal areas and activities.

The reports and documents available focus on the consequences of climate change for land-based coastal and marine activities. However, there is little emphasis on a framework for adaptation, specifically the mechanisms to identify and implement actions in response to current stresses and future changes in the environment. To address this gap, some consideration could be given on the steps that would promote and encourage an inclusive and effective adaptation plan, educate civil society and stakeholders, and facilitate the development and implementation policy framework.

Four documents are directly relevant to the climate change review:

- Climate Change Policy Framework for Jamaica, 2021
- Third National Communication of Jamaica to the United Nations Framework Convention on Climate Change
- Update of Nationally Determined Contribution (NDC) of Jamaica to the United Nations Framework Convention on Climate Change (UNFCCC), 2020
- The State of the Jamaican Climate 2019

Other relevant files include:

- Vision 2030 Jamaica – National development plan: medium term socio-economic policy framework 2018 – 2021
- Plan for Aquaculture Development in Jamaica, 2012 – 2025

The *Climate Change Policy Framework for Jamaica* (2021) (hereafter Policy Framework) provides an overview of recent evidence since the publication of the initial Framework document created in 2015. The updated Policy Framework led to the revision of principles and strategic policies to reduce risks of climate change impacts to Jamaica. This updated document is intended to support the goals of Vision 2030 Jamaica National Development Plan. The Policy Framework is built to address three main pillars: 1) *Strengthening of*

Jamaica's adaptive capacity and resilience to reduce its vulnerability to climate change; 2) *Pursuit of low carbon development and enhancement of access to and mobilization of climate finance*; and 3) *Promotion of public education and awareness raising, research and technology transfer towards ambitious climate action*. These aims set out the roadmap to implement policies that coordinate the national ambition to deliver on the obligations under the United Nations Framework Convention on Climate Change (UNFCCC).

The *Third National Communication of Jamaica to the United Nations Framework Convention on Climate Change* (2018) identifies actions implemented to achieve the objectives under the Paris Agreement. The report is structured in four sections providing an overview of national circumstances, up-to-date Greenhouse Emissions inventories, a description of key approaches and frameworks in adaptation readiness and capacity assessments. Finally, the document summarises the Jamaica's Government actions and future ambitions to mitigate climate change, reporting on actions to reduce greenhouse gases emissions, including features on the impacts of climate change, but not limited, to the marine environment and fisheries sector.

The *Update of Nationally Determined Contribution (NDC) of Jamaica to the United Nations Framework Convention on Climate Change* report (2020) summarises the ambitions and high-level mechanisms to support the successful delivery of commitments to reduce emissions by 2030. Central to this document is the observation that Jamaica's NDC are based on an implemented framework, policies and best practices that are governed a broader support and legitimacy, while ensuring economic growth (Vision 2030 Jamaica).

Finally, the *State of the Jamaican Climate 2019* report addresses contemporary and future climate scenarios for Jamaica. This document updates a series of previous reports and includes the incorporation of revised climate projections, an evaluation of risks and impacts based on available literature. This document contains 1) a baseline of information on climate change impacts in six priority sectors, including food, water, health, and economy and 2) a compilation of relevant resources for assisting decision-making processes in relation to climate change.

2.5. Gap analysis and further recommendations

Whilst there is a strategic climate change policy framework that sets out an ambitious approach to safeguarding a resilient marine environment and maritime economy in Jamaica, an integrated adaptation planning could help mitigate effects and ensure long-term sustainability of fisheries and aquaculture sectors. During this review, limited local sourced evidence-based data, could be identified and most available studies have regional scope.

Additionally, aquaculture production in Jamaica is high compared to other Caribbean nations. Despite the acknowledged importance for food security, the *Climate Change*

Policy Framework for Jamaica (2021) does not consider the aquaculture activities, and the *Plan for Aquaculture Development 2012-2025*, published in 2011, does not include mitigation plans for the sector. A Climate Change Risk Assessment for fisheries and aquaculture could be an informed source of evidence.

Further, a clear climate research agenda, set out by policy, would offer guidance on research needs to address challenges across sectors. There are multiple examples from the wider Caribbean region that would assist setting a plan to build resilience and reduce vulnerability through adaptation and capacity building[1]. The climate change adaptation for Caribbean fisheries document provides a good set of options to consider supporting the fisheries sector, which could also add further ideas to support the aquaculture and mariculture sectors.

To achieve successful outcomes, it is important that coastal communities participate in the research, planning, policy development and co-management at every stage of the process. This requires consideration of cross-societal issues, such as education, gender equality and inclusion of the Jamaican youth. Integration of traditional knowledge and local understanding of the skills and traditions could also play an important role in developing, informing and supporting an ecosystem-based fisheries management and development policy.

[1] Climate change adaptation for Caribbean fisheries 2021: taking action together - GOV.UK (www.gov.uk)

2.6. A Review of Climate Resilience in Jamaican Aquaculture

This review will cover 2 groups of documents. First, documents submitted by NFA colleagues for their potential relevance to Jamaican aquaculture. Second, based on the remit of the contract, recent publications on climate change impacts on the aquaculture sector, adaption recommendations, and background information on proposed species for production. This review will outline what the documents contain and their application to development of aquaculture in Jamaica.

Document List

1. Plan for Aquaculture Development in Jamaica 2012 – 2025 (2011)
2. National Fisheries and Aquaculture Policy, Ministry of Agriculture and Fisheries (2014)
3. Assessment of the Potential for Mariculture Development in Jamaica (2020)
4. Assessment of the Aquaculture Value Chain Incorporating Sensitivity to Climate Change – Final Report (2021)
5. Aquaculture Production Figures – 2010-2020
6. Climate Change and Aquaculture: Considering Adaptation Potential – Reid et al (2019)
7. Innovation, Practice and Adaptation to Climate in the Aquaculture Sector – Lebel et al (2021)

Document Summaries

1. **Plan for Aquaculture Development in Jamaica 2012-2025 (2011)** – This project was carried out by an FAO consultant in collaboration with MOAF and is cited by NFA officials as their current working plan. Although it goes into extensive detail about the aquaculture industry in Jamaica, it is very out of date and does not represent the current situation. It highlights several common issues in the aquaculture industry, such as rising costs of production, limited regulation frameworks, thefts, and a lack of effective organisation among producers. It also makes clear that, without government support for technical, organisational, and financial assistance, the industry will continue to struggle. With that in mind, the report proposes several goals considered manageable within 3 timescales – short-term (2012-2014), medium-term (2015-2019) and long-term (2020-2025). The short-term goals focus on: i) industry recovery, including support for restructuring and training the Aquaculture section, ii) enhanced communication with producers, iii) improved data collection practices, iv) development of operational plans, v) formation of a producer association, vi) production and promotion of Best Management Practices guides for current industries, vii) establishment of an Aquaculture Development Fund, viii) targeted improvements to the current

industries and exploration of diversification (e.g. Cobia and marine Tilapia), ix) survey and characterise the ornamental fish industry, and x) studies to assess the state of the local market for aquaculture products. The medium-term goals focus on: i) exploring new developments, including studies exploring both freshwater (e.g. Pangasius, Cachama, Bullfrogs) and marine (mangrove oyster, queen conch, snapper, red drum, sea urchins, sea cucumber, spiny lobster, Irish moss) ii) diversification options, iii) establish zoning and regulations based on diversification studies, iv) formulations of domestic and export marketing strategies, v) development and delivery of technology transfer and extension services, and a vi) public relations strategy. Long-term goals included: i) studies to identify possibilities in production and sale of brood stock/juveniles/seeds, ii) economic arrangements with neighbouring countries, iii) aquaculture-based fisheries, and iv) the development of production in previously studied diversification species. There are also recommendations for collaboration with the Rural Agricultural Development Authority to address producer organisational and marketing needs, setting up a stakeholder group to look at financial options available to producers, capacity building and laboratory investment for the veterinary services, and negotiating acquisition of knowledge and technologies from overseas.

2. **National Fisheries and Aquaculture Policy (2014)** - This policy document was drafted based on the recommendations outlined in Document 1. It gives a brief overview of the aquaculture industry of Jamaica, which is largely focused on Tilapia production and provides limited information on production of shrimp, ornamental fish, mangrove oysters, and Irish moss. Along with the issues outlined in Document 1, which persist, it also highlights losses due to climate events such as flooding and hurricanes. Finally, it delivers several high-level goals for improving the aquaculture industry, some of which are covered by the Fisheries Act of 2018 which gave the NFA authority to address many of the identified issues, including licensing and zoning within the aquaculture industry, dealing with release/escape of non-native species, and the mandate for aquaculture facilities to have management plans in place. Other goals are the subject of the dedicated consultancies under review by external parties, including the development of mariculture, build capacity for producers to participate in the value chain, and assessment of non-native species for potential use in aquaculture.

3. **Assessment of the potential for mariculture development in Jamaica (2020)** – This report is one of several from a recent World Bank project. It summarises the history of mariculture in Jamaica and points out that, from a commercial standpoint, mariculture is currently non-existent in Jamaica. Highlighted issues facing the establishment of mariculture include contamination from sewage, a lack of exclusive access rights to mariculture sites, high feed costs, and competition from imports. The market review highlights that Jamaica has a high per capita seafood consumption (25.23kg/year), the majority of which is from fish (22.86kg/year). An

estimated 40% of this comes from the domestic fresh fish market, and the remainder is from frozen retail products, over 98% of which are imported. It also points out that 60% of total seafood consumption is accounted for by the hotel and food service industries that cater to the predominantly tourist market. Recent growth in the export market, particularly to China, is suggested as a promising avenue to follow. This report refers to the importance of mariculture site selection, but do not provide any specific parameters for evaluation. Several species are reviewed in terms of their suitability for mariculture in Jamaica, with local varieties being favoured to reduce costs and limit the potential for disease introduction. The final selection was based on availability of documented aquaculture methods for the species, market demand for the product, and feedback from an extensive stakeholder consultation. Species recommended for medium- to large-scale mariculture were the local grouper and parrotfish, while species recommended for small-scale mariculture include Irish moss, sea cucumber, and mangrove oysters. The report also recommended establishing 'recirculating aquaculture systems (RAS) facilities for hatchery and nursery development and submersible cages for grow-out to withstand tropical storms. It was noted that the NFA is setting up a mariculture facility in Bowden Bay to demonstrate production of some of these species. The assessment points out the need to further develop the regulatory framework around the Fisheries Act (2018) to provide clear guidance on licensing, production standards, and monitoring. It also highlights the continued need for support in the form of capacity building, access to finances and investment, extension services, and research.

4. **Assessment of the Aquaculture Value Chain Incorporating Sensitivity to Climate Change – Final Report (2021)**

   This document reports the final assessment of the climate sensitivity of two value chains (tilapia and ornamental fish production) in Jamaica by ITACA Solutions. The methodology for their assessment was a 5-step process to characterize the value chains, assess the climate hazards present, evaluate current policies against these hazards, and engage stakeholders to validate the findings. The assessment of NFA policies against the adaptation needs to address these hazards followed published methodology from Crick et al. (2018). For the tilapia value chain, this report highlights ongoing issues with rising energy costs and a current monopoly in production of feed. Recommendations for this value chain include R&D work to diversify the industry and develop local feed ingredients, as well as an increase in the use of renewable energy sources and water efficient methods. The ornamental value chain suffers with bureaucratic export procedures, as well as a lack of investment and development within the industry, all of which lead to inconsistent supplies for export. Both value chains lack organisation among producers, which limits their ability to adequately promote their products, negotiate input prices, and access financial investment opportunities. Climate risks associated with each value

chain are discussed, with tilapia production being particularly at risk of rising water temperatures leading to decreased oxygenation and potential toxin accumulation, high winds and flooding from tropical storms causing extensive damage to infrastructure, power cuts, and drought conditions causing high evaporative water losses and water supply shortages. As most of the ornamental fish value chain is undertaken indoors, their main climate risks are from tropical storm damage to facilities or power cuts, and droughts leading to water shortages. Current NFA policies were found to offer adequate support to tilapia farmers to facilitate climate adaptation changes, but there is only limited support for other sectors in the value chain, such as input suppliers, processors, and vendors. There is also very limited direct support for the ornamental fish value chain. Based on these assessments, and the powers granted to the NFA under the Fisheries Act (2018), this report recommends that the NFA incorporate climate risk analyses into the development of aquaculture management plans, as well as undertake the production of three manuals – how to write a management plan for an aquaculture facility license application, design principles for climate smart aquaculture farms, and pre- and post-harvest best practices in aquaculture – based on FAO guidelines. It also recommends looking into finance options for supporting climate smart infrastructure, an extensive capacity building programme across both government staff and value chain members, and a strengthening of partnerships and collaborations across all sectors in the value chains.

5. **Aquaculture production 2010-2020**

During our literature compilation, a summary of key statistics was also produced as outlined in Table 1.

Table 1. Summary statistics of aquaculture production over 2010-2020 in Jamaica.

Yield (MT)					
Year	***Tilapia***	***Penaeus vannamei***	***Macrobrachium rosenbergii***	***Pangasius sp.***	**Total Production**
2000	4,500	-	0	0	4,500.00
2001	5,000	51	0	0	5,051.00
2002	5,851	144	0	0	5,995.44
2003	2,513	456	0	0	2,968.50
2004	4,200	~ 500	0	0	4,700.00
2005	4,200	~ 500	0	0	4,700.00
2006	7,543	476	0	0	8,019.00
2007	5,600	0	0	0	5,600.00
2008	5,800	136	12	0	5,948.00
2009	5030	105	5.6	0	5,140.60
2010	3,900	279.6	4.3	0	4,183.90
2011	1,100	45	4	0	1,149.00
2012	581.65	62.4	0	0	644.05
2013	785.9	50	0	0	835.90
2014	698	0	0	0	698.00
2015	645.77	0	0	0	645.77
2016	927.36	0	0	0	927.36
2017	1091	0	0	0	1,091.00
2018	1,186.11	0	0	0	1,186.11

2019	1,117.51	0	0.45	29	1,146.96
2020	911.75	0	0	0	911.75

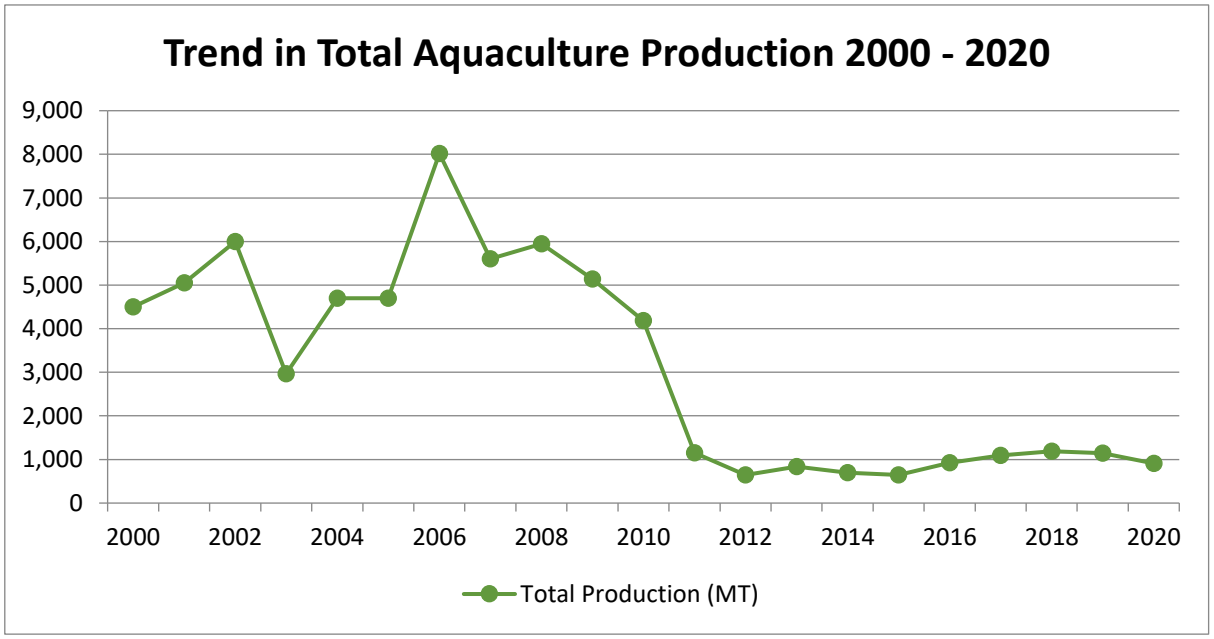


Figure 1. Summary trends in total aquaculture production (MT) over 2000-2020.

6. **Climate change and aquaculture: considering adaptation potential (2019)**
This paper from authors based in Canada is a review of current climate change factors that are expected to impact the global aquaculture industry and is aimed at producers, policy makers, and researchers. It provides a summary of the latest research on climate change factors that impact primary aquaculture production, including increasing water temperature, rising sea levels, changing weather patterns, ocean acidification, reduced availability of dietary components, and the impact of simultaneous stressors as it is likely that producers will face more than one of these factors. When discussing adaptations, the authors highlight that it is impossible to produce an exhaustive list of adaptations for every aquaculture scenario, so instead they focus on commonalities across multiple species and locations. Diet and nutrition are discussed with evidence linking food quantity and quality to increased tolerance to ocean acidification, high pCO_2, low pH, and increased water temperature. Feed sourcing is addressed, with recommendations on sourcing local feed alternatives, growing under-utilised alternative crops, and using mixed production systems, such as rice-fish farming. The authors highlight uses of selective breeding in selecting traits for increased tolerance to the changing environment, potentially incorporating genomics and molecular selection techniques. Several areas are covered in management and engineering solutions,

including flood and storm protection (improved infrastructure, natural mangrove barriers, offshore submersible systems), site selection and relocation of facilities, pond management (aeration, protective cover, water treatment), and diversification (integrated multi-trophic systems, stock and recapture). Improvements in information are suggested, including real-time monitoring of water quality and animal responses and early warning systems for natural disasters. Furthermore, long-term prediction models of environmental variables and disease outbreaks were suggested, though the authors note that most disease outbreaks in aquaculture are currently unreported, which makes modelling and planning adaptation strategies difficult. When addressing governance, they point out that the impacts of climate change on aquaculture are rarely addressed at the international level and national climate policies do not typically include management and adaptation strategies for the industry, which needs to change, in addition to regulatory processes streamlined to aid producers in making effective adaptations. Finally, the authors provide feedback to fellow researchers on knowledge gaps to be addressed, including a need for large amounts of high-quality environmental data at suitable spatial and temporal resolutions, as well as investment in large research facilities that can house multiple experimental aquatic units for full production cycles that can last months to years. They also highlight the requirement for multidisciplinary research to address the risks associated with multiple stressors, and for standardisation of climate research methodologies.

7. **Innovation, Practice and Adaptation to Climate in the Aquaculture Sector (2021)**

   This study looks at how innovations become adaptations within the aquaculture sector via practices. In the report innovation or practice are classified as contributing to adaptation to climate change if they control the environment to eliminate climate risks, reduce exposure to climate risks, enhance resilience to recover from climate-related impacts, or build capacity to adapt to climate risks. For this study, practices (i.e. daily activities) were broken down into 10 practice categories and, through a dedicated review, the authors address the progress of 3 innovations within each category that have led or could lead to climate adaptive practices. Technological material practices reviewed include aeration, filtration, and use of pellet feeds. Infrastructure material practices reviewed include dike construction for flood prevention, excavation of ponds for dry season water storage, and construction of indoor RAS systems. Ecological material practices reviewed include using mangroves for natural storm and flood protection, rice-fish systems, and integrated multi-trophic aquaculture. Biological material practices reviewed are selective genetic improvements, including improved tolerance for salinity and temperature changes, increased growth rate to reduce grow-out time, and resistance to disease. Technical procedural practices reviewed include adjusting fish stocking density, selection of feeding regimes, and water quality management. Institutional procedural practices reviewed include water allocation agreements,

licensing and zoning of aquaculture sites, and membership in a farm group/cooperative. Financial procedural practices reviewed include maintaining savings or convertible assets, access to credit services, and insurance schemes. Observational informational practices reviewed include monitoring fish behaviour, visually assessing water quality, and seasonal weather forecasts. Educational informational practices reviewed include farmer field schools, training courses, and distance learning/e-learning. Discursive informational practices reviewed include how activities are described, such as “climate-resilient”/“climate proof”/”climate smart” or “ecological intensification”/”sustainable intensification”. The authors found that most of the work on innovation and adaptation have focused on materials and technical practices. However, the evidence suggests social and institutional practices are important drivers of converting technological innovations to adaptations. They also found that innovations are not usually adopted independently, but as part of a package of related practices from across the 10 categories. These highlight a need to adjust from the typical knowledge-transfer/technology-transfer mindset to a more dynamic and inclusive approach. They also highlight the importance of timing and sequence to the presentation and adoption of innovations, i.e., is it addressing a current need and when/how often will it need to be done?

Potential Impacts of Climate Change in Proposed Species for Aquaculture in Jamaica

Current Disease Hazards

For fin fish in warm waters, numerous bacterial agents (species of *Vibrio*, *Aeromonas*, *Pseudomonas*, *Pasteurella*, *Streptococcus*, and *Mycobacterium*) and ectoparasites (*Amyloodinium ocellatus*, sporozoans, *Cryptocaryon irritans, Brooklynella* sp., and *Ichthyophthirius* sp.) are important pathogens (Tucker, 1999). The WOAH has listed aquatic animal diseases of significant importance to human and/or animal health. Table 2 outlines which WOAH listed diseases affect the proposed production species, as well as permissive conditions for the disease. There are currently no listed diseases for Irish moss, sea cucumbers, or parrotfish.

Table 2. Summary of WOAH listed diseases affect the proposed production species and the permissive conditions for the disease.

WOAH Listed Disease	Species Affected	Permissive Conditions
Infectious spleen and kidney necrosis disease (ISKNV)	Tilapia, Grouper	Water temperature >20 °C
Spring viraemia (SVCV)	Tilapia	Water temperature 10-22°C
Perkinsus marinus	Mangrove Oyster	Salinity >12 PSU, 1-2 months after summer maximum temperatures

Other key diseases of note that are not listed by WOAH are Tilapia Lake Virus in tilapia and Nervous Necrosis Virus of groupers. Tilapia Lake Virus can spread in a wide range of temperatures, while Nervous Necrosis Virus requires water temperatures >24 °C to spread most effectively.

Growth Preferences

In the wild, Nile tilapia (*Oreochromis niloticus*) may encounter a wide range of temperatures with strong seasonal thermal variations, from seasonal regions with warm (28–34°C) and cold (22–26°C) seasons or extreme environments with consistent temperatures, such as high altitude lakes (17–24°C) or hydrothermal hot springs (above 40°C), but the optimal growing temperature in a controlled environment is approximately 27–30°C (reviewed by Nivelle et al, 2019).

Nassau grouper (*Epinephelinae striatus*) showed optimal growth at temperatures between 28-31°C in a controlled environment (Ellis et al. 2011), but optimal reproductive rates at 24-27°C (reviewed by Kadison et al, 2010.).

Recent studies of *Crassostrea* sp. of oyster suggest salinity is the primary factor in growth, with the optimal range being 25-35% (250-350 PSU) and an optimum temperature of 24-28°C (Oliviera, 2018; Wang and Li, 2018)

There are several documented farming methods for *Graciliaris* sp. of Irish moss, and they have been grown in Integrated multi-trophic aquaculture systems (ITMA) systems (Wei et al, 2017). The greatest growth is typically observed during periods of warm water temperatures and extended day length (Marinho et al, 2009).

There are currently no well documented commercial production methods and figures for parrotfish (*Scaridae* sp.), though production for conservation has been undertaken by the Biota Group. Sea cucumber cultivation is a growing industry, though documented methods for *Isostichopus* sp. are limited to small studies in Ecuador and Mexico (Mercier et al, 2012).

2.7. Review of national level aquatic animal health biosecurity in Jamaica

2.7.1. History of aquaculture production in Jamaica

Jamaica clearly has the potential to expand aquaculture production (both the food and ornamental sectors) to support national food security and generate foreign exchange earnings through exports. Jamaica enjoys several advantages including suitable marine and freshwater environment, strong local demand (in part to meet the needs to the tourist industry) and proximity to international markets (e.g., North America). Plans for the regeneration of aquaculture in Jamaica (Wurmann, 2011) estimated a potential to produce food fish to a value of US $34-75 million by 2025, creating 3200 to 4000 jobs. However, since 2011 aquaculture production has not increased. Two of the main constraints are competition with imports and high energy costs. Wurmann (2011) concluded that Government had an important role to play in the revitalisation of the industry. The National fisheries and aquaculture policy review (2014; draft) proposed that the Government of Jamaica would 'establish, maintain and develop an appropriate legal and administrative framework that facilitates the responsible development and management of aquaculture'. The report commits Government to a number of biosecurity related actions, notably to: i) maintain Jamaica's disease-free status through strengthening of the Competent Authority and developing surveillance mechanisms for WOAH notifiable diseases, ii) promote the adoption of relevant international, sanitary and phyto-sanitary standards e.g. GAP, Hazard Analysis & Critical Control Point (HACCP), and iii) develop local standards and codes of good practices for aquaculture facilities.

A review of aquatic animal health capacity in Jamaica undertaken by Cefas in 2017 (Peeler and Stone, 2017) concluded that 'Currently disease is not a major issue for either the fish food or ornamental sector in Jamaica. The authorities evaluate, on a case-by-case basis, the disease risks associated with any proposed imports of live aquatic animals. This policy has proved successful, and evidence suggests that Jamaica is free of major internationally listed transboundary diseases such as spring viraemia of carp (SVC) and koi herpesvirus (KHV), as well as emerging diseases such as tilapia lake virus (TiLV).' Wurmann (2011) had also noted the potential value to the aquaculture industry of freedom from specific diseases. The ornamental fish sector was constrained because it was unable to export cyprinids to the US because SVC testing criteria for animal health certification could not be met.

3. Plans for aquaculture development in Jamaica

In 2011, a plan for aquaculture development (2012-2025) was prepared for the Government of Jamaica by an FAO consultant (Wurmann, 2011). The plan remains the current blueprint for aquaculture development in-country. The report highlighted problems facing the industry at the time of writing (loss of competitiveness, cheap imports), which accounted for the decline in output from 2008 onwards. It was concluded that intervention by the Government was required to revitalise the industry. The report sets out 3 phases of development. The first 3-year phase had three objectives: i) regain aquaculture's 'original thrust' and competitiveness, ii) reorganisation of producers and governance, and iii) regaining domestic market share. In the second, 5-year phase, the foundations for long term development would be laid, during which diversification into new species could start and export markets established. The success of stage 2 relies on both domestic and overseas investment. In the 3rd phase aquaculture would become a leading economic activity employing 3,200 to 4,000 staff. It was envisaged that 30% of food fish production would be exported. The plan set out three scenarios for projected production. In the most likely scenario, production values for 2025 were: tilapia – 11,041 t, other freshwater finfish - 1,104 t, shrimp 638 t, marine finfish 1,084 t, molluscs, and others 140 t. Currently, tilapia production is around 1,000 t per annum (compared with the optimistic scenario projection of 7,500 t). There is no marine finfish or shrimp production. Oyster production is extremely low and has not increased since 2011.

In 2020, a World Bank funded consultancy assessed the potential for mariculture development in Jamaica (AquaBioTech, 2020). The report reviewed previous projects including an EU funded 10 million JMD project (ACP Fish II) which proposed procedures and solution to support policy makers and other stakeholder. The plan recommended that a legislative framework that established authorisations and thresholds for environmental impacts be enacted, as a first step to encourage investment. The 2014 policy document was subsequently drafted. The AquaBio Tech (2020) report lists the following constraints to mariculture development: contamination of coastal waters with untreated sewage, rights to the foreshore, seabed and water column, high costs of feed, and competition from imports. The report highlights two categories of potential species for mariculture. It is suggested that species suitable for small scale production, requiring modest capital investment are oysters, sea cucumber, sea moss and conch. High value marine finfish species suitable for cage production, but requiring considerable start-up capital, include red porgy, grouper, snapper, cobia, dolphin fish, pompano and red drum. The report dismisses prospects for culturing tilapia in the marine environment because it is not a native species. Marine cage culture is only feasible if submersible structures are employed, which are resilient to extreme weather events. Shrimp production has been practised in the past based on the import of post-larvae. The report lacks any detailed economic analysis of the viability for the culture of any of the species referenced.

The 2019 consultancy (AquaBio Tech) noted that the introduction of pathogens and parasites from aquaculture to the marine environment as a risk which requires mitigation through biosecurity protocols, best management practices and emergency protocols. It is worth noting that the mariculture systems discussed in the report are 'open water' which allows free exchange of pathogens and parasites between farmed and wild populations. Therefore, the focus of biosecurity and management must focus on minimising the likelihood of disease introduction at a national level.

4. Review of existing aquatic animal health policy, legislation, and capacity

4.1. Policy

The most recent publications setting out aquaculture policy is the National fisheries and aquaculture policy review (2014; *draft*). The publication commits the Government to facilitate the development and management of aquaculture, specifically it proposed that the Government of Jamaica would 'establish, maintain and develop an appropriate legal and administrative framework that facilitates the responsible development and management of aquaculture'. The report commits Government to a number of biosecurity related actions, notably to: i) maintain Jamaica's disease-free status through strengthening of the Competent Authority and developing surveillance mechanisms for WOAH notifiable diseases, ii) promote the adoption of relevant international, sanitary and phyto-sanitary standards e.g. GAP, HACCP, and iii) develop local standards and codes of good practices for aquaculture facilities.

4.2. Responsibility

The Veterinary Services Division (VSD) of MAF in Jamaica has responsibility for aquatic animal health. Specifically, the quarantine, permitting and licensing unit regulates the import and export of all live animal and product, both terrestrial and aquatic.

4.3. Capacity

The VSD do not have any staff specifically trained in aquatic animal health (AAH), over and above their basic veterinary degree, or who have specialised in AAH.

VSD have good capacity in molecular diagnostics but no tissue culture capabilities and therefore, is not able to undertake surveillance for SVCV using the methods described by the WOAH.

4.4. Legislation

Aquatic animals fall within the scope of the Animal Diseases and Importation Act (Jamaica, 1948). The Act contains a 'schedule' of diseases, which are 'disease(s) within the meaning of the act' (article 11) and thus subject to control. No aquatic animal diseases are currently listed in the schedule, and thus in practice the legislation has not been applied to aquatic animals. The legislation provides specific powers to government to control animal diseases, notably to identify properties as infected (article 5) and to cull infected populations (article 8). The government has general powers to make regulations for the control and treatment of affected animals to prevent the spread of disease (article 12) and to enter premises (article 19). Regulations may cover the movement of people, animals and other items into or from infected premises, diagnostic testing, cleaning and disinfection. The legislation requires animal owners to notify an inspector of suspicion of a scheduled disease, but places no other obligations, for example, with respect to record keeping (e.g., mortalities, movements).

The National fisheries and aquaculture policy review (2014; draft) made a number of commitments related to regulation of the aquaculture sector, notably: i) to develop and implement a registration and licensing system for effective administration and planning for aquaculture, ii) geographic zoning of lands and water bodies for aquaculture. The Fisheries Act (2018) includes measures that go some way towards making the policy a reality. The Act establishes the National Fisheries Authority (NFA) with the function, amongst others, of 'monitoring, control, surveillance of any activity related to fisheries or aquaculture and any related activity'. Aquatic animal health management is clearly an activity related to aquaculture. The responsibility of the NFA compared with the VSD needs to be clearly defined. The NFA have responsibility for development, designation and zoning of aquaculture facilities and areas for aquaculture development. Biosecurity needs to be considered in aquaculture development and zoning of the marine environment for aquaculture. Specifically, the NFA needs to 'identify possible adverse environmental effects of an aquaculture activity', which may include pathogen introduction and spread. The VSD is the Competent Authority for aquatic animal diseases, i.e. the Governmental Authority with the responsibility for implementation of the WOAH international standards for aquatic animal health (see section 11 on resources). Specifically, the VSD are responsible for the reporting and control of diseases listed by the WOAH. However, clear overlap exists between the responsibilities of the NFA and the VSD. **It is recommended that NFA i) assess disease threats associated with proposals to develop aquaculture in collaboration with the VSD and using agreed risk assessment protocols, ii) in collaboration with VSD and other agencies update the Animal Diseases and Importation Act to take account of diseases of aquatic animals.** Collaboration between the NFA and VSD could be achieved by establishing a joint technical group to work on areas of shared interest, and notably to take forward the recommendations in this report.

Specifically, the Fisheries Act requires the NFA to ‘establish quarantine and control mechanisms’. The need for quarantine for animals imported for aquaculture depends on how the risks of pathogen introduction are managed. Under international standards, countries can rely on the health attestation of a country or zone exporting live AA. Lifetime quarantine is recommended for broodstock imported from sources not approved free of listed disease, allowing only offspring that test negative to be released.

An operator requesting to operate an aquaculture facility must conduct environmental impact studies (EIAs). EIAs should include assessment of disease threats. The Fisheries Act allows the NFA to invite the VSD, amongst others, to review the EIA. ***Specifically, it is recommended that NFA should invite the VSD to comment on the assessment of disease threats.***

It is recommended that the application includes a biosecurity plan which includes details of how mortalities are disposed of, how disease outbreaks are managed, record keeping, etc.

5. Identification of biosecurity hazards

5.1. Pathogen hazards

Pathogens of currently farmed species, which are likely to be absent from Jamaica, have been identified based on the WOAH disease listing and on-line searches and are summarised in Table 3.

Viruses of carp have emerged and spread globally mainly through the ornamental trade. There is no evidence that KHV, SVC or CEV are present in Jamaica (in either the ornamental sector, farmed or wild populations). TiLV has recently been listed by the WOAH. The virus is widespread but populations free of the virus remain. ISKNV has only relatively recently been detected in tilapia and it is likely that many populations remain free of the virus. Flavobacterium and RLO are not listed by the WOAH. It is possible that Jamaican carp are free of these pathogens, but in the absence of sampling, it remains uncertain.

Table 3. Pathogen hazards of major aquaculture species likely to be absent from Jamaica

	WOAH listed	Global distribution
Carp (*Cyprinus carpio*):		
Koi herpesvirus (KHV)	Yes	Globally widespread by KHV free source exist
Spring viraemia of carp (SVC)	Yes	Globally widespread by SVC free source exist
Carp edema virus (CEV)	Emerging	Identified in Europe
Tilapia (*Oreochromis niloticus*)		
Tilapia lake virus (TiLV)	Yes	Globally widespread by TiLV free source exist
Infectious spleen and kidney necrosis virus (ISKNV)	Yes	Recently identified in tilapia, many populations probably free
Flavobacterium columare	No	Globally widespread, disease-free populations not known
Rickettsia like organism (RLO)	No	Unknown distribution
Crassotrea rhizophorae		
Perkinsus marinus	Yes	Globally widespread

No important transboundary pathogens were definitively identified for *C. rhizphorae*. However, experimental challenge has indicated that *C. rhizophorae* may be susceptible to *Perkinsus marinus* (Bushek et al., 2002), but it is not a recognised host. A parasitological study of *C. rhizophorae* in Brazil found low levels of infection with Perskinsus spp.; other protozoa were also found.

Pathogens of penaeid shrimp are not considered in detail in this section as shrimp are not currently farmed. **However, if it is proposed to start shrimp farming, it is recommended that the Government of Jamaica should make a case based on the absence of susceptible species for freedom from all WOAH listed pathogens of shrimp.** Surveys may be required to meet WOAH standards to declare disease freedom,

5.2. Pathway hazards

There are two main pathways for pathogens to be introduced into Jamaica aquaculture production: the importation of live aquatic animals and sourcing of stock from the wild. Other less important pathways include the importation of contaminated pathogens and international shipping (carrying free living pathogens or infected animals in ballast water or via biofouling, Castinel et al, 2019).

6. Comparison of current practices against international standards

A report by Peeler and Stone (2017) concluded that revisions to aquatic animal health (AHH) legislation are required to meet WOAH standards for establishing disease freedom. This conclusion appears to remain relevant.

WOAH set out its international standards in the Aquatic Animal Health Code, which can be found online (see section 11 on resources). Chapter 1.4 of the Code sets out the principles of demonstrating disease freedom, and specific requirement for each disease are detailed in the disease-specific chapters. The WOAH set out a number of conditions that a country needs to fulfil before a self-declaration of freedom from a specified disease can be made (World Organisation for Animal Health (WOAH), 2017). Firstly, a country needs to meet basic biosecurity conditions, namely: a) the disease, including suspicion of the disease, is compulsorily notifiable to the Competent Authority; and b) an early detection system is in place within the zone or country; and c) import requirements to prevent the introduction of disease into the country or zone. Secondly, the country needs to be historically free or undertake surveillance to demonstrate, with a high level of confidence, that the pathogen is absent (i.e. 95% confidence that the pathogen was not present below specified design prevalence, normally at 2%).

To maintain freedom without continued active surveillance, the pathogen, if present, should produce identifiable clinical signs in observable susceptible species. Other conditions to maintain freedom also apply, notably that a) the basic biosecurity conditions are in place and effectively enforced; b) no vaccination against the disease has been carried out, and c) surveillance has previously demonstrated that disease is not present in populations of wild aquatic animal of susceptible species.

To meet WOAH standards revision of the current legislation would be required. Firstly, pathogens of aquatic animals would need to be listed diseases and an obligation placed on farmers, veterinarians and others to report suspicion of these diseases to the Competent Authority. Secondly, the legislation needs to give government powers to investigate disease outbreaks and take action to re-establish freedom (e.g., culling affected stock and restricting movements). Lastly, there needs to be a legal base to restrict imports of susceptible species for SVC and KHV to countries, zones, and compartments with the same status, and thus imports of susceptible species would need to be accompanied by health certification.

7. Review of legal basis of current standards and compliance with WOAH standards

Currently, Jamaica's AAH legislation fails to meet WOAH standards. Member Countries of the WOAH have an obligation to report the occurrence of diseases listed by the WOAH. The obligations are detailed in Chapter 1.1. of the code. The Government of Jamaica does not have surveillance systems or diagnostic capacity to detect and identify the occurrence of diseases listed by the WOAH. However, as Jamaica does not claim freedom from listed diseases, this lack of this capability does not compromise any current trade.

An important mandate of the WOAH is to reduce the spread of disease through international trade in animals and animal products. Establishing freedom from disease is the primary approach advocated by WOAH to achieve this end. WOAH lay down a number of criteria necessary which a country needs to fulfil in order to claim freedom from disease. Firstly, the pathogens of concern must be listed in legislation which places an obligation on stakeholders, notably farmers, veterinarians, and animal health specialists, to report suspicion of a listed disease (which should include reporting of elevated and unexplained mortality). Currently, Jamaica lacks this fundamental legislation as no aquatic animal diseases are listed in legislation. Secondly, a country wishing to establish disease freedom must have an effective early warning system, including the capacity to detect listed diseases and regulations to prevent the introduction of the pathogen (i.e. health attestation for imported susceptible species). **It is recommended that animal health legislation is revised to enable Jamaica to claim freedom from specific aquatic animal diseases.** Updating legislation is only the first step, investment needs to be made in capacity, specifically laboratory capacity, so that the Competent Authority has the means to detect listed diseases.

8. Biosecurity considerations and the role of Government in aquaculture development

The attribution of costs and responsibility for AAH between industry and government is, in the first instance, determined by the listing of diseases in legislation (Scutt and Ernst, 2019). Governments list both exotic and non-exotic diseases of aquatic animals which they wish to control using legal powers. Generally, diseases are listed which spread through trade and have significant impact on production or biodiversity. The primary animal health purpose of disease listing is to establish or maintain freedom at zone or country level. The control of listed diseases at regional or national level can only be achieved if there is an effective government funded AAH system. Strong national biosecurity, notably border controls, an early detection system and capacity to detect and control disease incursions are prerequisites to establish disease freedom. Each case for establishing disease

freedom needs to be assessed on its merit (and supporting economic models are presented in this report). However, a general argument can be made for investment in a national AAH system that creates options to establish freedom and encourages private investment in aquaculture. Developing economies require support from international organizations (e.g., WOAH, FAO) and trading partners to develop biosecurity, implement standards and fully benefit from the system of sanitary safety in trade established by the Sanitary and Phytosanitary Agreement of the World Trade Organization (WTO, 1995; Peeler and Ernst, 2019).

A weak national AAH system may lead to industry investing in biosecurity (including laboratory capacity) at farm (compartment) level. Generally, only large export-oriented enterprises will be able to make necessary investment in farm level biosecurity. Whilst investment by industry in biosecurity should be welcomed, investment in biosecurity at zone or national level, which depend on government intervention, is likely to be a more efficient use of resources with benefits across the sector.

It can be argued that the control of endemic pathogens, through for example, vaccination, prophylactic treatment, breeding for resistance and optimal management (stocking policies, water quality etc.), is primarily a private good, and, therefore, costs properly fall to industry. This is generally the case in developed economies with effective private provision of animal health services. However, governments may choose to support (or even impose) disease control measures, such as vaccination, that contribute to wider government goals of, for example, economic growth, rural employment, reduction in AMR, food security, and protection of biodiversity and natural capital.

Whilst tilapia production has fallen from a peak of around 7,000 mt in 2007 to around 1,000 mt annual production in over the last few years there are signs of recovery. Disease is not considered a major challenge to production. Competition from imported fish and high energy costs are frequently cited as constraints to expanded production. However, exotic diseases, notably tilapia lake virus, are a threat if imports of broodstock are permitted. Whilst there is a system to review imports of live fish, there is no clear legislative basis to restrict live fish imports based on the sanitary status of the source country, zone or farm.

Jamaica is free of a number of important transboundary diseases. It is critical that plans to develop aquaculture include improving national biosecurity to ensure that Jamaica continues to benefit from its high health status. There is an opportunity when starting a new aquaculture development to ensure that it is established on a regulatory basis that places obligations on farmers to maintain a high level of biosecurity (and record keeping) and provides Government powers to control listed diseases. However, investment in Government infrastructure, notably laboratories, early detection systems, surveillance, is needed to implement a national aquatic animal health system.

9. Recommendations for investment in biosecurity

Public money to support biosecurity and aquatic animal health management is always limited and, therefore, needs to be carefully targeted. Some elements of strategy need to be fully elaborated; notably the high-level objectives (generation of rural employment, foreign exchange or national food security) should inform the selection of sites and species for aquaculture development. The following steps, which are further elaborated below, are recommended to ensure resources used to support aquaculture are prioritised, and that an appropriate national biosecurity policy for Jamaica is tailored to the aquaculture development strategy.

Key recommendations
1. Through consultation between stakeholders and government, agree priority species for aquaculture development.
2. In consultation with industry, Government funds economic analysis of aquaculture initiatives to support decision making by investors.
3. Government identifies zones in the marine environment for mariculture and determine number and size of farm per zone, based on EIA and epidemiological considerations.
4. Based on the target species and production systems, requirements for importation of live aquatic animals to i) establish local broodstock, or ii) as a long-term production plan (e.g. the import of juveniles) are identified.
5. Key pathogens of target species are identified (see Table 1).
6. The government assesses case for self-declaration of disease freedom for the identified pathogens using WOAH standards and templates and determines what surveillance and investment in national aquatic animal health is required to meet WOAH standards.

At a national level, the Government has committed itself to a number of biosecurity related actions, notably to: i) maintain Jamaica's disease-free status through strengthening of the Competent Authority and developing surveillance mechanisms for WOAH notifiable diseases, ii) promote the adoption of relevant international, sanitary and phyto-sanitary standards e.g. GAP, HACCP, and iii) develop local standards and codes of good practices for aquaculture facilities. Recommendations to support the Government meet these commitments are discussed below and summarised in Table 4.

Investment by Government in biosecurity should be viewed as one element of a raft of measures that are required to support the development of aquaculture in Jamaica. It is important that biosecurity (and climate resilience) is integrated into the planning for aquaculture. For example, a decision about the creation of maritime zones for aquaculture, and the granting of licences need to take into account, aquatic health management and biosecurity considerations.

The selection of target species for aquaculture development is fundamental to the development of a biosecurity strategy. The biosecurity risk and, therefore, mitigation measures can be formulated based on the projected reliance of imported stock (continual or one off) or on wild caught stock. For example, penaeid aquaculture relies on importing broodstock, or the continual introduction of post-larvae. Appropriate policies, underpinned by legislation, are required to minimise the risk of introducing exotic transboundary shrimp pathogens. Firstly, important pathogens of the target species should be identified. Secondly, these pathogens should be listed in legislation which places an obligation on farmers and others to report suspicion of disease and give the Competent Authority powers to control the pathogen if detected. Where possible Jamaica should declare freedom from these pathogens. It is highly likely that investment in methods of detection (that meet WOAH standards) may be required. An effective early detection system for the listed exotic pathogens is required. Government should ensure that producers are required to report suspicion of listed disease (and increased unexplained mortality). If production is dependent on wild caught stock, it may be advisable to quarantine and screen stock for important pathogens before their use as foundation broodstock. This recommendation applies particularly to marine finfish species. It is suggested that the Government of Jamaica request that the WOAH undertakes an evaluation of the Performance of Veterinary Services (PVS) (gap analysis) of aquatic animal health services in Jamaica[2]. The results of the analysis can be used to prioritise funding and seek support from international donor agencies.

In the marine environment, the creation of zones for mariculture development and a process of farm authorisation that grants right to the foreshore and seabed is critical. Biosecurity considerations need to be considered in zoning for aquaculture and farm authorisation. The density of farms within and zone, the distance between zones and local hydrodynamic conditions need to be considered when assessing the likely spread of pathogens between farms and zones.

The National fisheries and aquaculture policy review (2014; draft) proposed that the Government of Jamaica would ‘establish, maintain and develop an appropriate legal and administrative framework that facilitates the responsible development and management of aquaculture’. To this end, it is recommended that as a condition of authorisation, farms are obliged to maintain a biosecurity plan tailored to their production system and

[2] https://www.oie.int/en/document/pvs-aquatic-tool-2021/

circumstances. Specifically, there should be an obligation, as a condition of authorisation that farmers keep records of mortalities, animal movements and mortality. The NFA, in collaboration with the VSD, should produce a biosecurity plan template.

Potential investors are only likely to start funding new aquaculture facilities once they have a full understanding of start up and running costs (some of which are determined by Government capacity and policy, e.g. conditions of authorisation, requirement of EIA, limits of production or stocking levels), and risks. Disease is an important economic threat to production. Investors will examine Government biosecurity and disease control policy to assess the likelihood of the introduction of important exotic pathogens and secondly, the efficacy of the Government's response to disease outbreaks. The Government may choose to fund economic assessment of specific aquaculture initiatives to demonstrate the potential returns on investment.

Table 4. Summary of recommendations to support the development of aquatic animal health management.

	Recommendation
1.	Request that WOAH evaluate the Performance of Veterinary Services (PVS) (gap analysis) of aquatic animal health services in Jamaica[3]
2.	Identify target species and locations for aquaculture development
3.	Identify key exotic pathogens of target species
4.	Revise legislation so that key exotic pathogens are listed in legislation and the CA has powers to control listed diseases.
5.	Invest in AAH capacity to enable Jamaica to claim freedom from key exotic pathogens f target pathogens
6.	Establish system of health attestation for imported live AA
7.	Self-declare disease freedom of important exotic pathogens to WOAH standards and based on the WOAH template
8.	Establish a register of aquaculture business, and require that farms are authorised by the Government

[3] https://www.oie.int/en/document/pvs-aquatic-tool-2021/

9.	Lay down conditions of authorisation, including a biosecurity plan and records keeping (i.e. mortalities, treatments and movements) (develop blueprints for records keeping and biosecurity plan).
10.	Establish databases and information networks to collect, share and disseminate data related to aquaculture activities
11.	Fund sector specific economic analysis to support investment in aquaculture and aquatic animal health

10. Conclusion

The 2014 review makes clear commitments to support aquatic animal health management and specifically national biosecurity as part of its plans to revitalise aquaculture in Jamaica. The 2018 act was an important first step in laying down the legislative basis for a well-run industry. In this report recommendations are made for investment in guidance, capacity and skills, which are necessary for the 2018 act to be fully implemented.

Disease presents an increasing threat to wild and farmed aquatic animal populations for two main reasons: i) a growing industry importing live aquatic animals and bringing wild capture animals into farmed production and ii) the emergence of new disease driven by climate change. It is important that Jamaica recognises the threat of disease introduction that may arise from an expanding and acts (see recommendations in this report) to minimise the risks. Specifically, there is a need to invest in AAH capacity so that Jamaica can self-declare freedom from important pathogens of key aquaculture species and put measures in place to protect that freedom. Enhancing capacity in AAH management, and ensuring a respond to disease outbreaks, reduces the impact of both introduced and new emerging diseases. Jamaica's aims to grow its aquaculture production twinned with the increasing threat new emerging diseases creates a strong case for investment in national aquatic animal health capacity.

11. Resources

The table below provides website addresses to key WOAH and FOA aquatic animal resources:

Resource	URL
World Organisation for Animal Health – Aquatic Animal Code	
WAHIS: World Animal Health Information System:	https://wahis.woah.org/#/home

information on the occurrence of listed diseases by country	
Glossary: Definition of basic biosecurity system required to demonstrate freedom from disease	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=glossaire.htm
Guidance on establishing freedom: Principles: Chapter 1.4 aquatic code Guidance on susceptible species, design of structured surveillance in disease specific chapters (sections 9, 10 and 11)	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/ https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=sommaire.htm
***Obligations for disease reporting*:** Reporting of listed and emerging diseases	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_notification.htm
Biosecurity for aquaculture establishments: Provides guidance on biosecurity measures to minimise spread of disease	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_biosecu_estab_aqua.htm
Zoning and compartments: Guidance on establishing disease free compartments and zones	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_zon_compartment.htm
Import risk analysis: Guidance on assessing disease risks associated with imports	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/?id=169&L=1&htmfile=chapitre_import_risk_analysis.htm

of live animals and commodities	
World Organisation for Animal Health – Aquatic Animal Manual	
Diagnostic assays Description of diagnostic assays to the detection of listed pathogens in pathogen specific chapters Guidance on selection of animals and tissues.	https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-manual-online-access/
Information of disease epidemiology: Prevalence, mortality, morbidity, reservoirs of infection, vectors, pathology, transmission	

11.1. Institutional/Capacity Assessment

The literature review was presented and discussed over several workshops between Cefas/MRAG and NFA and relevant stakeholders. These discussions enabled to identify and map the list of relevant stakeholders (including government) entities with responsibilities for fisheries and aquaculture management based on past and current projects. The overall assessment is presented in the summary table below for NFA's consideration. It is important to confirm whether the stakeholders on the list are all relevant towards the development of the Framework for Climate Resilient Fisheries and Aquaculture Management.

The Cefas/MRAG team in collaboration with the NFA team compiled a list of potential themes, key organisations and dedicated examples for capacity building (e.g. personnel qualifications, responsibilities, integrations and complementarity of roles) (Table 5). This information was screened to map the whole extent of agencies, roles, responsibilities and assess if any overlaps exist under the current structure, responsibilities, and conflicts with other agencies (including government and non-government organizations) responsible for natural resource management. A key component of the institutional / capacity assessment is based on relevant stakeholder roles that hold responsibility (or may be given the responsibility) for carrying out these tasks and verify national stakeholder capacity against each task.

Table 5. Summary matrix, with examples of relevant themes, key parameters, level of capacity rating, training choice to build capacity and the dedicated local, regional international organisation that could be considered to support the partnerships for capacity building and knowledge transfer. Capacity ratings described as follows: Excellent= 5; very good=4, good=3, fair=2, poor=1.

Themes	Capacity rating	Explanation of the rating choice	Identified opportunity to build capacity	Identified partnerships to meet capacity
Legislation (climate)	4/3	The staff have the basic and relevant understanding and training. There are international and regional	Further training to support local and regional understanding of current and new climate requirements	Links to the following organisations: • CRFM • Caribbean Community Climate Change

		drivers to support this level of work		Centre (5Cs) • IPCC
Planning **(Fisheries)**	4	The staff has different levels of training and understanding of these practices	• Further training opportunities should be explored with local agencies and Fisheries Agencies to ensure dedicated 'up-dates' on new planning of fisheries stock assessments and analysis. • Dedicated training to undertake stock assessment and evaluation	Links to the following organisations: • CRFM • MOAF • Technical Working Groups (e.g Conch coalition TG) • ICES • Cefas
International Aquatic Animal Health Standards	3	The staff understand key principles of on which international standards are based	Further training is suggested to ensure that national aquatic animal biosecurity meets international standards	Links to: • WOAH regional office, • CRFM, • FAO regional office.

Further discussions with NFA colleagues (Mrs. Avery Smikle *pers. comm*.) suggested that the main engagement groups for consideration will be:

- The Climate Change Division - funding for climate change adaptation and mitigation is targeted at this Division who determine climate change projects that will be developed and implemented
- National Environment and Planning Agency
- Forestry Department
- Beach Control Authority
- Water Resources Authority
- National Land Agency
- Port Authority of Jamaica
- the Planning Institute of Jamaica who have a responsibility for planning and projects.
- Ministry of Finance - responsible for management of funds related to climate change
    - Veterinary Services Division
    - Water Resources Authority
    - National Irrigation Commission

Whilst all these groups mentioned above are important stakeholders with whom the NFA interacts, it will be important to consider aspects related directly to aquaculture. The work conducted by Engelhard et al. (2022) provides a sound methodology on climate vulnerability assessments under climate change conditions for the aquaculture sector. There is also a need to integrate across disciplines and sectors should consider the following organisations to support capacity building, training, and climate change knowledge transfer activities:

- Ministry of Economic Growth and Job Creation (MEGJC)[4]
- Climate Change Focal Point Network (CCFPN)
- CRFM and Caribbean Climate Change Community Centre

[4] *MEGJC – Achieving prosperity through economic growth and sustainable development*

- Main activities under this umbrella- Sustainable Finance
- Dedicated programmes (e.g. The Pew Charitable Trusts, WWF and The Caribbean Biodiversity Fund)

There are further specific which could be considered by integrating with other local and regional bodies. These suggestions are listed below:

Cross-cutting collaborations with regional bodies that are also conducting climate change capacity building activities are:

- Caribbean Climate Change Community Centre (5Cs),
- Caribbean Regional Fisheries Mechanisms (CRFM),
- Central players in regions (e.g. FAO)
- United Nations Universities in region (e.g., University of West Indies) will be good to contact and ensure further linkages to support capacity building activities.

Dedicated research- to assess the effects of climate change across sectors could take the form of climate vulnerability assessments for fisheries (see Pinnegar et al., 2019) and aquaculture (see Engelhard et al., 2022). These types of exercises could be undertaken as a screening assessment to evaluate which resources and pressures could be most at risk in Jamaica's fisheries and aquaculture.

Sustainable Finance- climate change increasingly affects fisheries globally, the need is growing to support fishers in their responses and adaptation to its impacts (Barange et al., 2018). Changes in storminess—both changes in adverse weather conditions (e.g. wave height, heavy rainfall, wind) and extreme events (e.g. tropical cyclones, storm surges and flooding)—are projected under future climate change (Sainsbury et al., 2018). Financial compensation from insurance is being increasingly advocated to support fishers in their recovery and adaptation (Oerther, 2016; Barange et al., 2018; Tietze and Van Anrooy, 2018; Sainsbury et al., 2019). Some of the recent weather-based index insurance schemes (or parametric insurance) provide one opportunity to facilitate rapid post-extreme event responses.

Jamaica is one of the most risk adverse places to climate change effects, due to their location in one of the worlds' most active hurricane basins. Similarly, other factors such as sea level rise, stronger tropical storms, rising temperatures and intense rainfall events could be also some of the likely expected effects.

It is important to add that Jamaica has been supported by the InterAmerican Bank as part of the climate investment fund. Over the years, there has been dedicated collaboration to

support waste management, housing, and infrastructure and energy sectors to ensure preparedness to climate across these areas[5].

Further financial support across the topics identified can be provided by both domestic and foreign bodies, ranging from large international financial institutions (e.g., the World Bank) to smaller environment funding NGOs (e.g., The Pew Charitable Trusts, Worldwide Fund-WWF, and The Caribbean Biodiversity Fund) and preferential purchasing agreements.

Recently, there has been an increase in financial institutions giving focus to climate change related strategies and programmes through a variety of mechanisms e.g. multilateral climate funding institutions (i.e., governed by multiple national governments) include the Green Climate Fund (GCF) and Inter-American Development Bank (IDB).

Others include debt-for-climate (or debt-for-nature) swaps, where debt accumulated by a country is repaid in local currency and redirected to domestic projects that boost climate mitigation and adaptation activities. The Environmental Foundation of Jamaica, a grant making institution, was founded because of a debt swap initiative[6]

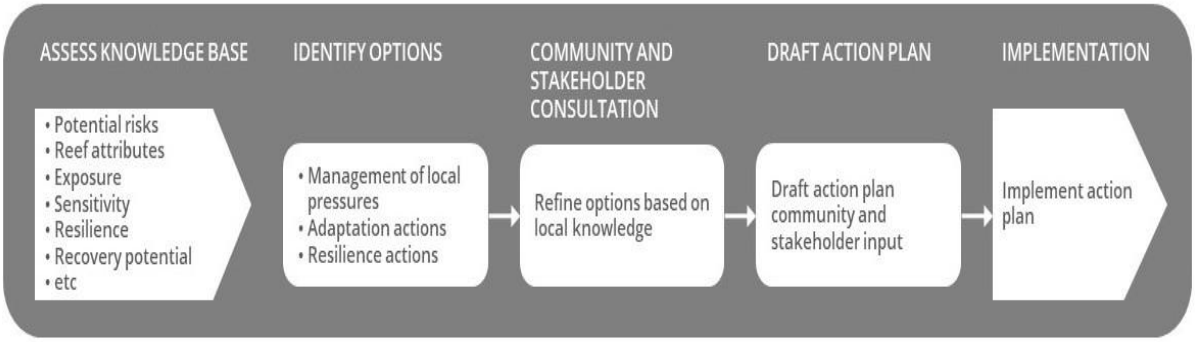
12. Draft action plan and road map implementation

The information gathered from reports, synthesis, online workshops, and overall feedback have been considered for drafting key initial areas, to support the first draft of the Strategy and Action Plan for National Fisheries and Aquaculture Policy. The process considered takes account of the 5 key stages (assess knowledge base, identify options, stakeholder engagement, drafting of the action plan and implementation) see Figure 2.

Figure 2. An Overview of the framework for the inclusion actions that are to be considered for developing a climate change adaptation and resilience building action plan in support of fisheries and aquaculture in Jamaica (adapted from Lincoln et al., 2022).

[5] Progress Toward Climate Resilience Jamaica.PNG (1153×889) (climatelinks.org)

[6] https://jis.gov.jm/efj-provides-record-grants-to-54-organisations/



In Jamaica and for the whole Caribbean, fish are important resources, supporting food security and of cultural importance. Therefore, when it comes to considering a strategy for the fisheries and aquaculture sectors, it is important that climate change adaptation is at the heart of this planning. There are some key impacts of climate change that are constantly being experienced by marine species and habitats which have direct consequences for biodiversity, fisheries, and aquaculture, which need to be considered.

Therefore, the summary of key topics to address includes monitoring & assessment, surveillance, capacity building, funding, evaluation, and governance. These should be part of the institutional mechanisms for assessing progress, identifying the roles and responsibilities of the range of stakeholder institutions, guided by Fisheries Departments.

It is also important to consider that not all the adaptation actions suggested below are solely of the responsibility of National Fisheries Authority or management institutions. As some of these actions, will be cross-cutting responsibilities of government ministries and agencies.

It is also important that the Strategy document takes account of new, emerging pressures (e.g., new species, invasive non-native species, pathogens and new pathways of introductions).

Adaptation planning in the fishing and aquaculture industry should be included in national planning and development and recognised for its importance locally, regionally and internationally.

The NFA policy documents presented by during the start of this process do provide a supportive environment for the growth of the Jamaican aquaculture industry and its adaptation to more climate resilient practices with the view for diversification opportunities.

The current consideration of mariculture potential discussed a demonstration multi-trophic facility at Bowden Bay, and communications (A. Smikle, 2021) with the NFA confirming that they are currently pursuing financial support this development.

The value chain assessment (see summary by Reid et al., 2019) points to a continued lack of organisation among producers in the tilapia industry, but the availability of data on the ornamental fish sector is a welcome addition.

The passing of the Fisheries Act (2018) has addressed several of the regulatory concerns around zoning of aquaculture facilities brought up in the development plan and communications with the NFA highlighted that while there is good knowledge of areas which are suitable for aquaculture/mariculture development, much more work needs to done in terms of the demarcation and development of these zones (A. Smikle *pers.comm*., 2021).

Current adaptation options for the climate risks highlighted in the value chain assessment (3.3.4) are well summarised by Reid et al (2019) and further details on their implementation are available from “Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options” (FAO,2018). However, focusing purely on the available technology and methods misses out on key social and infrastructure components to successful adoption of these changes, as highlighted by Lebel et al (2021). This further supports measures which have been brought up as points of concern in nearly every document reviewed – organisation and representation of producers, understanding of the available markets, and suitable financing for expansion of the industry. While these topics are outside of the remit of this project, they are vital to the successful uptake of any climate adaption measures proposed.

When designing climate resilient aquaculture policies, it is best to focus on things we can control including species selection, facility design, and site selection. Many of these have been alluded to in previous consultations.

A summary of key findings, activities, timelines, and outcomes that could assist with a Strategy and Action Plan for National Fisheries and Aquaculture Policy are provided in Table 6.

Table 6. Summary overview of key areas for consideration as a first draft of the Strategy and Action Plan for National Fisheries and Aquaculture Policy.

		ACTIVITIES			
Topic	**Objective**	**Phase I (0-2 years)**	**Phase II (2-5 years)**	**Phase III (5+ years)**	**Outcome**
Research & Assessment (fisheries and climate)	To assess and monitor different components of the fisheries (dynamics, gear used, landings of the key species, conch and spiny lobster/ fish communities)	Build local research and assessment capacity (data analysis on the fisheries components and stock assessment)	Develop and acquire a centralised repository (e.g. data portal, training portal and materials to capture and centralise the data)	To participate at local and regional technical working groups to present, showcase and acquire new methods and 'best practice' examples.	To generate and sustain an active and healthy fishery (in accordance with national and international obligations)
Research & Assessment (fisheries and climate)	To generate a climate risk assessment to evaluate the climate resilience of resources (Thermal sensitivity, habitat type, Low-oxygen/pH hazard and predator vulnerability)	Deliver a scientifically robust evidence-based information on current and future changes across fisheries	Generate understanding on risks and pressures from human activities (e.g. generation and ongoing updates of Marine Spatial Plans) including climate change effects– to prepare dedicated users and the overall sector	Continue to document and apply regional models and economic assessments ('scale up magnitudes of effects')	To generate and sustain a climate proof fishery (in accordance with national and international obligations)

Research & Assessment (aquaculture and climate)	To draft key recommendations for biosecurity and climate resilience adaptations to be included in future aquaculture management plans.	Deliver state of the knowledge on climate proof aquaculture practices	Generate understanding on risks and pressures (multiple-stressors e.g. temperature, oxygen, pH, pollutants)-to support/prepare the sector	To explore options for AHH national biosecurity (including laboratory capacity) at farm (compartment) level, supported by Government intervention for a more efficient use of resources.	To support coastal and marine aquaculture practices (in accordance with national and international obligations)
Research & Assessment (aquaculture and climate)	To generate a climate risk assessment to evaluate the climate resilience of resources (Thermal sensitivity, Flooding and storm surge exposure, Low-oxygen hazard and Disease vulnerability)	To generate knowledge on aquaculture and climate vulnerability assessments.	Generate understanding on risks and pressures (multiple-stressors)-to support/prepare the sector	To explore options for climate adaption practices (e.g. water quality, new species, etc.)	To produce a CRA for 3 species (mangrove oyster, Irish moss, grouper) with mariculture potential based on current and predicted climate conditions in Bowden Bay, see Engelhard et al. (2022).
Capacity building	To develop local and regional capability to support training and development across organisations.	To support and streamline policies and activities across sectors/organisations	Active communication and engagement for effective collaboration with local and regional bodies	Active engagement with regional organisations (e.g. CRFM) and TWGs to support partnerships and R&D needs	Multi-sectoral co-ordination across policies and organisations for implementation and action.

Governance (stakeholders)	To develop awareness and support across stakeholders and sectors of the revised climate/fisheries and aquaculture policies	To build trust, understanding and joint responsibility for fisheries and aquaculture resources	To promote co-location of activities and joint planning	Share the costs of licenses, monitoring and assessment of key areas	To promote integration across sectors of fisheries, aquaculture under changing climate adaptation
Finance (funding)	To support improvements in real-time for monitoring helping with zoning, planning and integration for aquaculture.	To improve water quality and animal responses, as well as early warning systems for natural disasters.	To achieve high quality of healthy and profitable products	To generate long-term prediction models of environmental variables and disease outbreaks	To support and improve the development of coastal and marine aquaculture practices
Finance (funding)	To support improvements in gear, recording and net zero practices for fisheries. Dedicated financing could support dedicated R&D advancements.	To improve adjust to new techniques and reduce carbon footprint.	To record catches, quotas and prices for responsible fishing practices	To explore deep water fisheries and other alternatives species	To protect and support sustainably fisheries.

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