Montserrat Sargassum Adaptive Management Strategy (SAMS)
Volume 1: Adaptive Strategy

27 March 2023

Working draft

Table of Contents

Preface

Sargassum science, management and uses are all very current and dynamic. Technical and scientific information on sargassum can quickly become outdated, and much is still contested. At the 3rd UWI Sargassum Symposium, held 9-10 March 2023 in Barbados, scientists, practitioners and resource users acknowledged many uncertainties about sargassum and the way forward. They also recognised the need to plan for and manage sargassum using the best available data and information in integrated and adaptive approaches.

This Sargassum Adaptive Strategy (SAMS) addresses how to implement such approaches. It treats the influxes of sargassum seaweed experienced in the Caribbean since 2011 as both threat and opportunity. The strategy for action based on resilience thinking, climate adaptation and disaster risks offers guidance to stakeholders in the sargassum pre-influx, influx impact and post-influx phases. It recommends using data and information for decision-making and learning from monitoring and evaluation in order to adapt.

The adaptive strategy (Volume 1) and action appendices (Volume 2) cover many aspects of managing sargassum. Critical to the strategy are the site profiles that set out social-ecological characteristics, history of impacts and responses, vulnerabilities, opportunities and other features relevant to each site. The institutional arrangements for response have these site-level building blocks as their foundation, similar to community-based disaster management, while scaling up to national level to match the requirements of very massive influxes that call for major mobilisation. This update is an interim guide.

The strategy is meant to fit within an integrated intersectoral framework and multi-stakeholder scope of national adaptive management such as climate change adaptation, disaster risk management and blue economy initiatives. Collaboration and coordination of diverse actors can support SAMS success. To persist with fragmented business-as-usual will not. We know this from lessons learned since the first draft SAMS were done in 2021 across five Eastern Caribbean countries. Some key lessons included that:

- The concept of a national SAMS focusing on strategic adaptive management is acceptable
- There has been no wholesale implementation of any SAMS, but content is used selectively
- SAMS have encountered problems typical of most Caribbean marine resource governance
- Strategies and plans are not usually implemented due to high political-institutional uncertainty
- Adaptive management is contrary to customary, risk averse, public service business-as-usual
    - Sargassum leadership is often quite unclear with frequent changes in responsibilities
    - Sargassum authorities, where identified, are often under-resourced for their mandates
    - Sub-optimal results to learn from, via monitoring and evaluation, are seen as “failure”
    - Adaptive management is perceived as risky, and is constrained by a fear of “failure”
- National intersectoral coordination mechanisms are weak or absent for most marine resources
- Institutional arrangements for proactive public private partnerships are often in early stages
- Other state or sector priorities reduce resources (financial, physical, human, etc.) for sargassum
- Formal authority is often circumvented by informal social networks for creative implementation
- Good practices in climate change adaptation and disaster risk management are often not used
- Adopting and implementing a SAMS now would be a transformative change for most countries
- Regional and national geo-political bodies have no enabling policies for such a transformation
- SAMS technical-scientific content and recommended actions can be acceptable as “stand alone”

This 2023 draft SAMS builds on the 2021 drafts and the above lessons. SAMS 2023 Volume 1 adaptive strategies are all intentionally very similar as there are few strategic differences among the sargassum

situations in Caribbean islands. The SAMS will await formal approval by the key authorities. Formal approval implies assuming full ownership of SAMS such that they are continually updated and evolve to build required resilience into responses to sargassum.

Acknowledgements and disclaimer [to be done]

Glossary of sargassum terms

Some common terms have been adopted to have specific meanings in sargassum science. A few of them used in the SAMS are explained below. Additional terms and meanings will be found in other documents.

Beaching	Synonymous with *stranding* but applies to only sandy shores rather than also rocky shores or hard surface shore protection
Brown tide	Plume of brown, poor quality water that occurs when sargassum dwells in the nearshore and starts to degrade releasing pigments and fragmenting into fine brown particles
Golden tide	Fresh, healthy, bright golden-brown rafts of sargassum floating out at sea; has the potential to contribute to an inundation and/or stranding
Influx	Arrival of sargassum into a broad area (e.g., the Caribbean Sea, Mexico's EEZ etc.)
Inundation	Arrival of large amounts of sargassum overwhelming shorelines and bays where it beaches or is trapped
Invasion	A term to be avoided since pelagic sargassum does not really fit the definitions of an invasive species and it is native to the North Atlantic
Mat	Densely packed *raft* with irregular round or teardrop shape measuring a few to hundreds of metres across
Pelagic sargassum	Common term (lower case, not italics) referring to the mix of floating sargassum species and their morphotypes. 'Holopelagic' may be used to emphasise this is for the entire life cycle
Raft	Aggregation of floating sargassum (as opposed to scattered thalli), generally classified into two different forms — *mats* and *windrows*
Sargasso	Term for *pelagic sargassum* generally preferred by Spanish speakers but does not imply that the seaweed originates from or dwells in the Sargasso Sea
Scientific names	Sargassum is properly named in scientific and technical work by using a particular format. This includes genus, species and morphotype, capitalised and italicised as shown here: *Sargassum fluitans* II, *Sargassum natans* I and *Sargassum natans* VIII. Use *Sargassum* spp. To refer to more than one species of sargassum. Except in its scientific names, sargassum need not be capitalized or italicized when used as a common name for the seaweed in sentences.
Stranding	Arrival of sargassum on the shoreline and can be synonymous with *beaching*. The preferred term for sargassum on accumulating on rocky shores and hard surface shore protection
Windrow	*Raft* of sargassum generally arranged in a long line from a half to several metres in width

1 Introduction

Since 2011, large influxes of sargassum have been affecting the western Atlantic Ocean, becoming a recurring threat in the Eastern Caribbean. This includes Anguilla, British Virgin Islands (BVI)[1] and Montserrat, although these northern islands have not been as severely impacted as some southern islands to date. The influxes have resulted in increasingly negative ecological and socio-economic impacts with biodiversity loss in coastal and marine ecosystems; health impacts associated with emissions of hydrogen sulphide and ammonia; and economic and livelihood impacts in the tourism, fisheries and marine transport sectors. The influxes show no sign of lessening.

This 2023 draft SAMS is a deliverable of the project on "*Sustainable sargassum management in Anguilla, British Virgin Islands and Montserrat*" that aims to implement a participatory and multi-level approach to manage sargassum influxes to protect and enhance coastal and marine biodiversity and associated livelihoods. It is being implemented from 2021-2024 by the Caribbean Natural Resources Institute (CANARI) in collaboration with Department of Natural Resources – Anguilla; Ministry of Natural Resources, Labour and Immigration – BVI; Department of Environment – Montserrat; Centre for Resource Management and Environmental Studies (CERMES) of the University of the West Indies; and the Organisation of Eastern Caribbean States (OECS) Commission. It is funded by a grant from the Darwin Initiative but also draws on outputs from the CERMES project on *Adapting to a new reality: Managing responses to influxes of sargassum seaweed in the Eastern Caribbean as ecosystem hazards and opportunities* (SargAdapt)[2].

1.1 Context

Whether sargassum is treated primarily as a threat or an opportunity, and the consequent situational vulnerability or resilience, depends on several factors in any country and site-specific situation including:

- Exposure (e.g., quantity in influx, duration, seasonality, location of inundation or stranding)
- Sensitivity (e.g., ecology and biodiversity of area, human habitation, poverty, public health)
- Adaptive capacity (e.g., funds, skills, response through disposal, use as raw material input)
- Maladaptation (e.g., established bad practices, inappropriate institutional arrangements)
- Adaptation (e.g., overall enabling climate change and disaster risk policies and practices)

At the 3rd UWI Sargassum Symposium, held 9-10 March 2023 in Barbados it was reiterated that there are several unknowns and uncertainties about sargassum[3]. However, it was generally agreed that sargassum in small to moderate quantities can be ecologically and socio-economically beneficial (to household, small business); larger quantities can be ecologically and socio-economically harmful and need to be managed adaptively (including industrial scale commercial use); while the largest inundations are likely to become natural disasters about which little can be done but recover and rehabilitate responsibly (akin to storms). Reasons for why excesses of sargassum seaweed pose problems for many economic sectors, some ecosystems and human health are becoming known, but the best available information on sargassum is constantly changing. An active approach to keeping up with good practices and uses is required in adaptively managing sargassum.

Adaptive management is, in practical terms, an approach to testing (e.g., concepts, information, practice), with collective learning through monitoring and evaluation (often participatory), so as to iteratively make better evidence-based decisions and improve management actions. A management strategy, rather than management plan, is aimed at enabling and systematically setting out the structured flexibility required to support adaptation. Adaptive management strategies contribute to

building resilience against surprises and perturbations such as massive sargassum influxes but are not yet commonly used in the Caribbean.

Feedback from the five countries for which SAMS were drafted in 2021, and some others without SAMS, is clear and consistent in acknowledging the potential benefits of adaptive management strategies. The these countries also state that they have not made any progress in this regard since influxes were first experienced in 2011 (see Preface for details). In summary, sargassum stakeholders report that:

- Adaptive management is not practised for any marine natural resource issue
- Frequent changes of policies, authority and personnel frustrate management
- Uncertain and inadequate budgets and other resources constrain responses
- Unrealistic expectations and misinformation persist at all levels of society
- Ecological and technical challenges are compounded by institutional issues

1.2 Content

This 2023 draft is very similar to the 2021 draft SAMS but, reflecting an adaptive management approach, it enhances the original by incorporating new knowledge and learning acquired in the intervening two years. Since the 2021 draft SAMS was sparingly used and not formally approved in the intervening period by those countries which received it, this draft contains less on specifying governance and more on technical and scientific aspects of management. Guidance is offered without being prescriptive given the dynamism of sargassum situations. Should this draft be finalised by the relevant authorities, it will need to be edited to reflect current conditions and actors as well as prevailing knowledge at the time.

The content of this draft SAMS Figure 1) includes how to engage the strategy and reviews key adaptive approaches. The next sections are the SAMS purpose followed by some guiding principles. The scope of the SAMS and its authority come next to clarify what it does or does not cover. Institutional arrangements follow. Then national to site level actions and operations are introduced, but these are more comprehensively addressed in detail in Volume 2 action appendices. The final sections are financial considerations and further action.

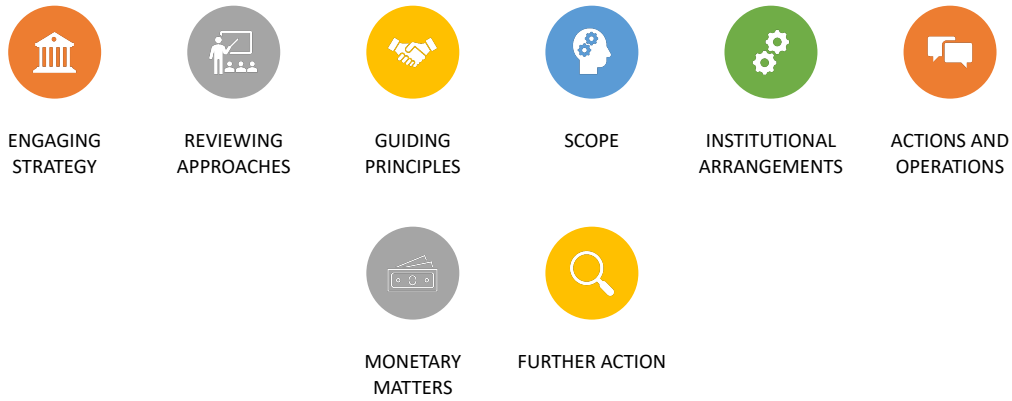


Figure 1. Content of the draft SAMS Volume 1

Each section ends with a call-out of three critical questions for authorities to answer in their approval. This acknowledges that in some cases there may be a need for prior use of the participatory research and monitoring (PRAM) framework to supply evidence to facilitate formal approval of the draft SAMS.

There may be other questions, but three which apply to governance in most Caribbean islands are selected. This does not imply that the SAMS should not be used prior to formal approval. To the contrary, it demonstrates the benefits of dynamic documents that evolve with evidence to adapt to current conditions. The step of formal approval largely adds policy-based leverage to SAMS implementation.

2 Engaging the strategy

This sub-section addresses engaging the SAMS. Readers familiar with sargassum management and resilience concepts may benefit from reviewing the adaptive strategy (this Volume 1). Readers focused on sargassum adaptive management operations may wish to focus on the action appendices (separate Volume 2). Both volumes inform and support SAMS implementation but also need engagement and communications strategies to become functional. This is typical of participatory natural resource management (Figure 2)[4].

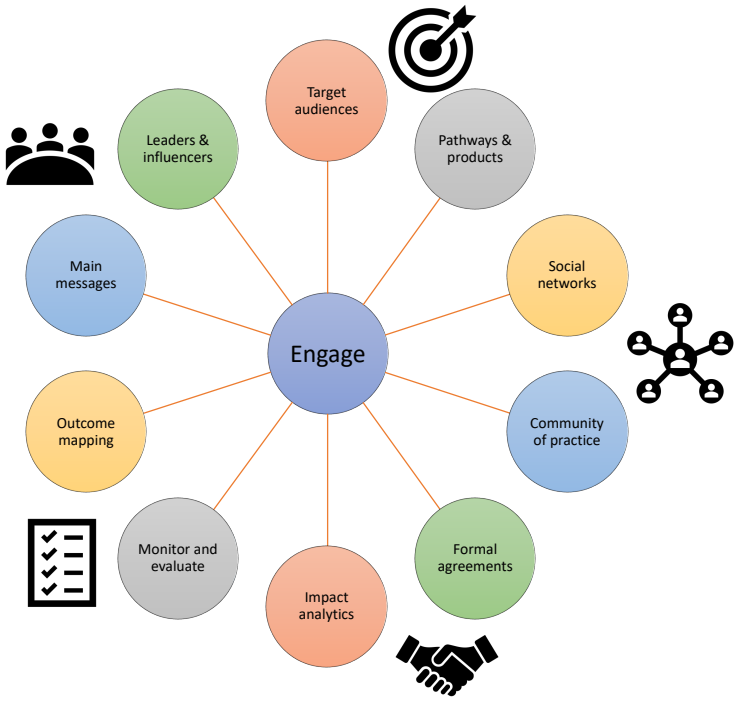


Figure 2. Components of engagement including communication strategies

Note that, to be concise, the draft SAMS does not provide the history and background to Caribbean Sea sargassum influxes, nor does it deliver a country situation or scoping report. Both the contextual and current situations with sargassum can be found in other resources[5]. To meet the challenge of frequent changes in information SAMS users must be able to quickly find up-to-date resources on what they specifically need to know about sargassum to fill gaps in knowledge for informed decisions and action. Notes and links in both volumes direct readers to website resources that are typically kept current. The SAMS should be integrated into the communications[6] of national sargassum authorities[7] to promote benefits of collective societal implementation and to support a blue economy[8].

Sargassum science and technology is expected to continue evolving rapidly. Ideally the SAMS should be converted into interactive web pages or remain in electronic document format rather than be printed. If

the SAMS content is actively updated as a living document there will be no need for it to be re-issued except for major revisions. Select SAMS pages, linked web pages and resource downloads can be printed by users on demand. An online environment assists social media communications with stakeholders.

The SAMS is meant to be accessible and understandable by specialists as well as the public, but some technical and scientific terminology is necessary. Translating (jargon or a foreign language) and updating content could be largely self-organised by a contributing community of SAMS users who have oversight and validation/verification of information coordinated by a recognised sargassum authority. This 'wiki' collective and active engagement is becoming more popular and can complement citizen science.

SAMS users are expected to span local to national levels of governance in society including government, civil society, academia and the private sector. Collectively, better informed decisions and action can be taken at the most appropriate institutional or geographic level practicable, scaled to match sargassum response needs. The SAMS cannot address all known or unforeseen circumstances. Hence social and institutional learning and adaptation are critical features for which adaptive capacity will need to be built to confer resilience. Engagement through learning networks and groups, local community and organisation initiatives are likely to be more successful and useful than focusing upon engagement by individuals[9]. As engagement and communication are critical to the success of the SAMS, readers will need to peruse the abundant Caribbean and other guidance resources on this topic. Based upon engagement, SAMS approaches that contribute to achieving societal resilience are reviewed in the next subsection.

Three critical questions for authorities to answer in the SAMS approval process:
Is enough known, through identification and analysis, to engage the key stakeholders?
Has engagement been designed to be adequately inclusive of key stakeholder diversity?
Are means of engagement appropriate to the key stakeholders made clearly available?

3 Review of adaptive approaches

The SAMS addresses sargassum influxes primarily as threats, but also as potential opportunities especially for livelihood innovation and entrepreneurship (Figure 3). Both threats and opportunities must be addressed via inter-sectoral coordination and stakeholder collaboration (Figure 4).

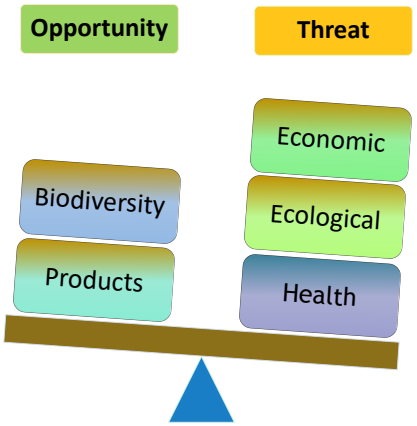


Figure 3. Balancing threats with opportunities

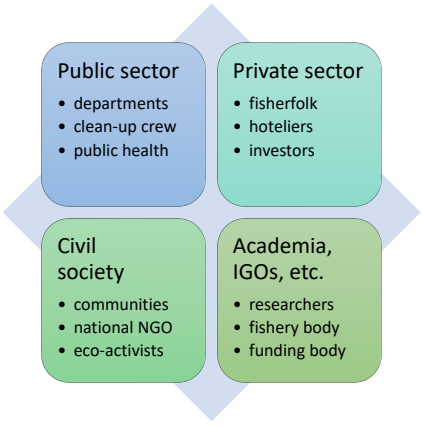


Figure 4. Coordination and collaboration are critical among key stakeholder categories

Key stakeholders (Figure 4) differ by level of governance and location, but they must be identified in order to develop sound institutional arrangements. One approach to proceeding systematically is adaptive management (Figure 5). Adaptive arrangements must be considered when applying a disaster cycle (Figure 6) approach to sargassum.

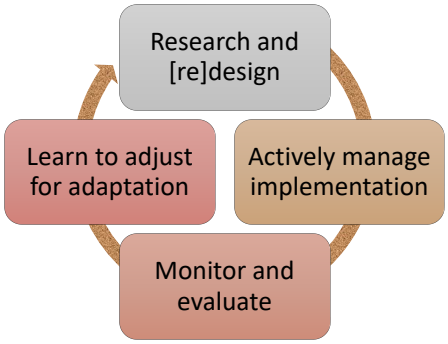


Figure 5. Adaptive management is needed to address the uncertainties and complexity

Figure 6. The classic disaster cycle is useful, with limitations, for sargassum (Source: Wikimedia Commons, all rights waived)

Sargassum is not always a hazard and a threat to economy and society. Its uncertainties, often with extended duration of impact, make it different from some other, more predictable, hazards. However, much established guidance from disaster risk management (DRM) is relevant[10]. This includes the assessment of vulnerability and adaptive capacity; risk assessment; hazard monitoring; threat level decision-making; vulnerability mapping; community-based, but multi-level, management; and planned sequences of proactive and responsive interventions in a DRM cycle. Vulnerability is a function of exposure and sensitivity, modified by adaptive capacity that builds resilience (Figure 7)[11]. Adaptation and maladaptation are respectively the good and bad outcomes of our actions to learn and intervene to change the environment and/or society. Several human dimensions interact in complex ways to determine all the above components of vulnerability usually considered in climate change adaptation[12].

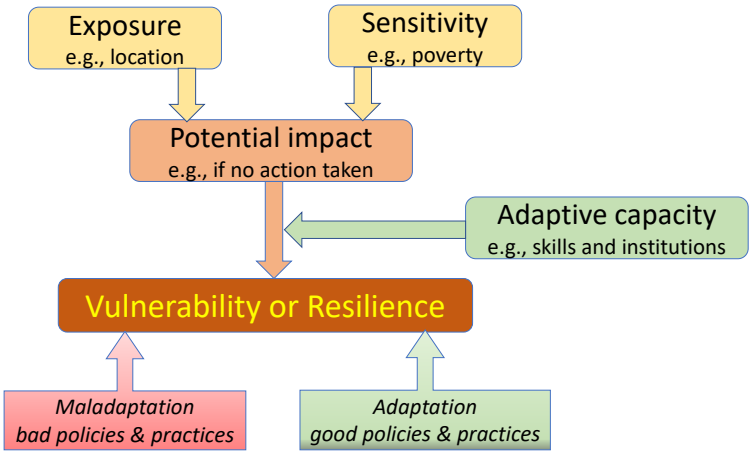


Figure 7. A vulnerability perspective on threats includes building adaptive capacity and resilience

For opportunities, the appropriate guidance is less in scientific literature than in industrial engineering, commerce, marketing, knowledge mobilization etc. However, all of these need to be supported by scientific data and information (natural science, social science, interdisciplinary and transdisciplinary).

Adaptive approaches facilitate better decision-making than less informed strategies. But 'book knowledge' must be complemented by practical learning-by-doing … another cross-cutting theme. Better and more collaborative planning and creation of adaptive capacity, particularly for innovation, is needed to build resilience against sargassum influxes (Figure 8).

Figure 8. Building social-ecological system resilience is a long-term goal in addressing sargassum influxes

The reasons for repeatedly emphasising the above concepts throughout the SAMS is that short term, coping, reactive and uncoordinated responses to sargassum may have the appearance of being busy and productive, but in the medium to long term they may exhaust resources, do damage and erode stakeholder engagement without much real advancement. We must collaborate and adapt for the longer term, considering our inter-generational ecological and social responsibilities for stewardship.

Three critical questions for authorities to answer in the SAMS approval process:
With which set of adaptive approaches does sargassum adaptive management best align?
Which adaptive approach offers the best opportunity for leveraging resources and success?
In what ways is any adaptive approach either a major asset or liability at the policy level?

4 Purpose and principles

The purpose of this strategy is primarily to build resilience to threats from influxes of sargassum seaweed, turning the potential threats where possible into adaptive opportunities for sustainable development (social, economic, environmental). The SAMS is based on guiding principles to inform readers on what to aim for, e.g.:

- Using integrated, participatory, good practices such as ecosystem-based approaches, climate change adaptation, disaster risk management, sustainable and blue economic development, etc.
- Complying with all applicable global, regional, sub-regional and national agreements, policies and similar instruments of policy guidance whether binding or non-binding
- Establishing formal and informal arrangements for good and effective governance with strong links from local to national level in order to scale up and down responsive action

- Providing an enabling environment for local level networks, self-organisation, livelihood opportunities, socio-economic community development and building adaptive capacity
- Ensuring that sometimes necessary coping strategies do not unduly constrain the longer-term adaptive strategies necessary to maintain resilient social-ecological systems

Although extensive lists of guiding principles may be drawn from various instruments, the list for action must be kept short and high-level. Elaboration of principles can be pursued in the references and other documents.

Three critical questions for authorities to answer in the SAMS approval process:
What purpose and set of principles from which policies are most strategic for sargassum?
Which principles are widely applied in practice in marine governance, and are adaptive?
Which principles are common enough to guide participatory monitoring and evaluation?

5 Scope

The sargassum authority will revise the scope of the SAMS from time to time in its communications. It will communicate expectations that are realistic and limitations that are acceptable. Some examples follow.

5.1 Expectations

Incorporating the preceding guiding principles, the governance scope of the SAMS is from the local to national level with weaker links to sub-regional and regional levels. It encompasses key state and non-state actors in sargassum management, whether or not formally considered stakeholders. Unless it is given clear legal or administrative authority the strategy is for guidance only and is non-binding. Considering SAMS audiences:

- Average citizens may expect the state to handle sargassum without their active involvement, e.g., for beaches to be cleaned of sargassum regardless of the severity of stranding or location
- Economic sectors (e.g., tourism and fisheries) may expect preferential treatment and priority allocation of resources to address their concerns as resource-dependent coastal enterprises
- Civil society may expect transparency, accountability, equity and other aspects of good governance from the political and public administration processes
- Environmental advocates may seek biodiversity conservation and ecosystem health as priority
- Entrepreneurs may expect the state to facilitate financial and technical assistance for product research, development and expansion of sargassum uses regardless of the risks
- Political actors may expect that sargassum issues will be resolved, without their active leadership, by science and technology within politically relevant timeframes and not persist as their problems

The above and other expectations may not be realistic as small island resources are scarce. The situation is worsened when there is little cost recovery in management via revenue generating uses. False

expectations should not be allowed to develop or persist as this distorts and influences information for decisions and action. Instead, an evidence-based communications campaign should foster confidence in multi-stakeholder partnerships that include non-state actors by raising awareness about potential opportunities and correctly prioritises sargassum management action based on agreed criteria such as via risk assessment and benefit-cost analysis. Sargassum trade-offs lead to consideration of limitations.

5.2 Limitations

As a framework for planning, a SAMS is not prescriptive. Instead, it guides good practices and no-regrets high-level action, aiming to have decisions and action updated through testing, monitoring, evaluating, learning and adapting. However, there are practical limitations to expectations. In broad terms a SAMS:

- Cannot guide all good practices or anticipate the most appropriate practices for every eventuality.
- Will require site and situation-specific action to improve from learning-by-doing, good monitoring and evaluation, and with frequent updating of knowledge in electronic format, also incorporating user contributions and local knowledge.
- Should have its national level complemented by local or community level management plans. These plans, at finer operational scale may be more akin to prescriptive blueprints and be less adaptive due to their fit.
- Can make it easier for people to understand and follow detailed instructions that are less variable at the local level by illustrating the national bigger picture in a coherent manner.
- Will require actors to be aware of its adaptive design so that its changing content as implementation proceeds is appreciated as a desirable feature of adaptation to which users can contribute, rather than perceive change as a consequence of deficiency.

The SAMS requires managing expectations and limitations with attention to decision-making and action that may not be equal for all. Equity is a factor in implementing the SAMS. To some extent the scope of the SAMS will depend on the sargassum actors and institutional arrangements in place.

Three critical questions for authorities to answer in the SAMS approval process:
Is the scope sufficiently broad to accommodate the sargassum variability and uncertainty?
Is the scope sufficiently deep to allow adequate data, information and decisions for adaptation?
Are the expectations and limitations realistic given the diversity of stakeholders and situations?

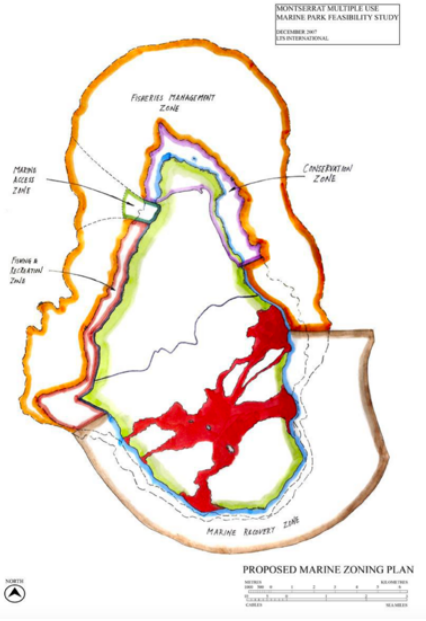
6 Institutional arrangements

The SAMS must enable good and effective multi-level governance for action and adaptation[13]. The institutional, geographic, jurisdictional and ecological scales of management decisions should match sargassum threats and opportunities to the extent possible. Scoping illustrated a number of these dimensions through various maps which will be invaluable for the SAMS to be coherent (Figure 9).

[a] Topographic

[b] Tourism

[c] Fish landing sites



[d] Ocean zones

Figure 9. Maps of Montserrat (a-d) inform issues and institutions (Source: scoping report)

Institutional arrangements should be comprehensive, but agile enough to take quick and informed authoritative decisions and delegate actions as necessary at the most appropriate level from national to local. This will be challenging. Establishing authority and good relationships is key. A summary of generic institutional configurations is in Figure 10.

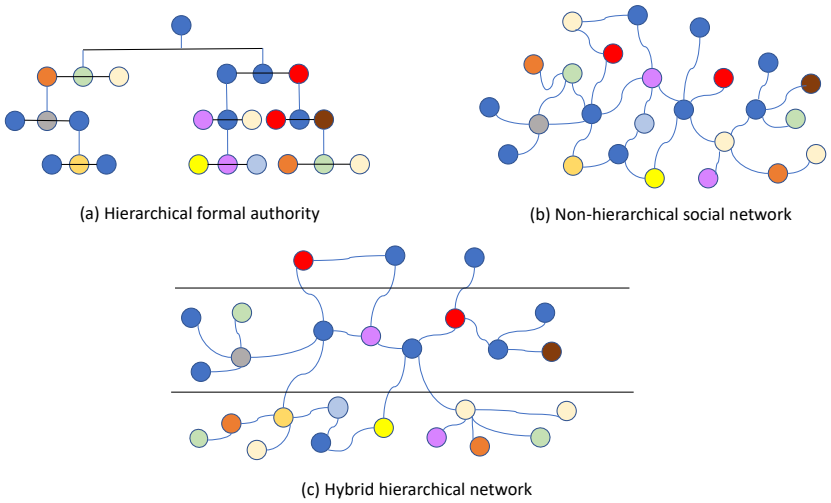


Figure 10. Structures of institutional arrangements

In the diagrams the nodes (coloured circles) can represent individuals, groups or organisations depending on the scale and type of analysis. The connecting lines can represent relationships such as authority or communication and collaboration. While nodes that are well connected may be or become leaders with authority this is not always the case. A hybrid or combination type of organisational structure maybe the most appropriate for the SAMS flexible implementation, but this is yet to be systematically tested for learning. Formal hierarchies (e.g. in the public sector and some firms) can be too rigid to easily adapt while social networks (e.g. in communities and some NGOs) can be too fluid to institutionalise adaptation. Adaptive governance is required to strike a balance that is likely to differ by country, level of governance and the scale of the activities required of the institution.

6.1 Authority

A SAMS derives authority from key policy documents and laws that should integrate ecosystem-based and participatory approaches. One expects that a SAMS will receive direct high-level endorsement via the Cabinet or a senior Minister if it is to be properly implemented. Due to the complexity of sargassum threats and opportunities, the strategy cuts across several sectoral policies, plans and laws (e.g. coasts, tourism, fisheries, energy, manufacturing, etc.) in the blue economy. Unless a sargassum authority is identified and is fully empowered to lead the SAMS adaptive management will struggle to gain traction as a preferable approach for dealing with the high uncertainty, dynamic challenges.

The most relevant legal and administrative instruments at this time are listed in Vol. 2 Appendices. This list must be regularly updated to maintain coherence across sectors and issues. Legislation specifically for sargassum may not be needed, but it must be clear what pieces of legislation are relevant. Ideally, legal extracts and explanations should be combined into a communication product suitable for all actors (state and non-state) and types of response (hazard and use) to be adequately covered with clear authority.

6.2 Institutions

Adaptive approaches to governance will be needed to adjust the institutional arrangements for sargassum, after sufficient evaluation and learning, to fit the country's changing circumstances. Such

adjustments are not system failures. Yet, very frequent adjustment or abandonment without sufficient learning is as unproductive as retaining arrangements that are ineffective. Adaptive governance will be a novel experience, quite different from business as usual. For example, a large pool of committed stakeholders (see Vol. 2 Appendices) can be set up and reconfigured on demand into *ad hoc* task forces or working groups to address situation-specific issues without becoming cumbersome or mired in bureaucracy. Regardless of structure, the leading sargassum authority must have good linkages from local coastal site to national level. Aligning sargassum management with zones such as used for marine protected areas, integrated coastal zone management, tourism, marine spatial planning, fisheries and national ocean policy are also relevant[14].

Three critical questions for authorities to answer in the SAMS approval process:
Is the authority with formal mandate for sargassum effective at the science-policy interface?
Are the institutional arrangements for sargassum consistent with the engagement strategy?
Is there sufficient policy influence and practical capacity to support adaptive management?

7 Actions and operations

There are no plans or strategies in Montserrat that directly address sargassum influxes. The SAMS places emphasis on regular updating, especially of the Vol. 2 Appendices. Separate sources of information can be combined as needed to be fit for the purpose at hand in any place or situation. For these reasons this section is short. Details are in the Vol. 2 Appendices in both the location-specific (Part A) and general Caribbean (Part B) sections. An overload of information is as counterproductive as too little, especially if the skills, time and criteria for selecting information are limited among the diverse SAMS potential users. Thus, both volumes aim to be concise despite the huge and growing subject.

In this section we divide the SAMS into three phases: pre-influx, influx impact and post-influx (Figure 11). A glossary of specialized sargassum terms is provided at the start of this publication for further guidance. This is important for consistent communication. Here we explain a few for convenience. An 'influx' refers to the arrival of large amounts of fresh sargassum offshore that results, often patchily, in many site-specific 'inundation' episodes. Influxes and inundations can be prolonged and persistent such that they overlap in time and space rather than be distinct events. 'Pre-influx' and 'post-influx' may both feature persistent or degraded sargassum onshore or nearshore. We use 'stranding' for sargassum that has washed ashore, but some authors use beaching instead. 'Mats' or 'rafts' refer to free-floating masses of sargassum with additional terms also being applied to specific features.

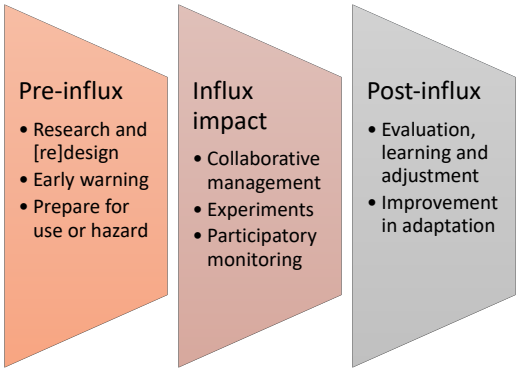


Figure 11. Segmenting the SAMS into phases can make the strategy more efficient and effective

Uncertainty demands systematic adaptive action rather than avoidance of planning and management. Sargassum uncertainties include event timing, location, amount, composition, impacts, responses and learning. The last is critical for reducing some uncertainties but, similar to climate change and variability, the limited options for mitigation argue for higher national priority being given to successful adaptive management strategies rather than to primarily refining prediction on the presumption of greater precision leading to better outcomes[15]. Amongst the Vol. 2 Appendices, the site profiles are particularly important for informing action tailored to specific locations. All SAMS site profiles in Vol. 2 follow a set template of maps and tables (Figure 12).

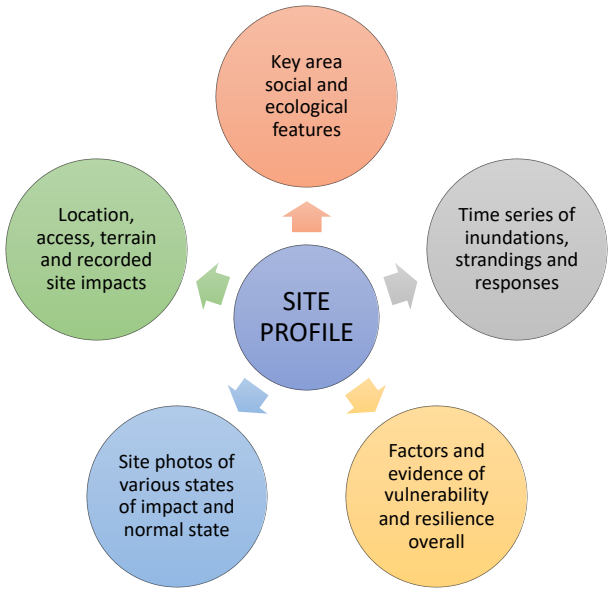


Figure 12. Template components of SAMS Vol. 2 site profiles

These SAMS site profiles are simple observational and secondary data summaries that require minimal resources to compile and can be implemented through participatory (community or other) processes and citizen science. They can be considered a bronze standard. A silver standard would be to add information from drone surveys (also called PUAS[16]) and other digital sources. The highest standard can extend to full geographic information system (GIS) integration such as done for DRM and climate change adaptation in some places. If sargassum science in included in climate and disaster policies and practices reaching the gold standard should be feasible. Having the site profile data and information online and open can foster and facilitate collaboration to find appropriate responses to and uses for sargassum. Several actions and operations in the three phases will rely on good site time series information and open access to data.

7.1 Pre-influx

Similar to some other poorly predictable natural hazards there needs to be an almost constant state of readiness for rapid adaptive response to sargassum. Critical components, in Vol. 2 Appendices, include:

- Monitoring sargassum accumulations and oceanic tracks from far offshore into the EEZ via remote sensing and early warning systems

- Receiving, perusing and sharing information from the Eastern Caribbean sargassum outlook bulletin and other web and email sargassum services including discussion groups
- Subscribing to news alerts and website feeds that tag and share sargassum articles and stories
- Ensuring that guidelines covering sargassum adaptation, clean-up responses, uses for products and so on are disseminated to and easily accessible by all
- Establishing a sargassum phone hotline, using existing social media sites and other means for anyone to share information on sargassum throughout the disaster cycle
- Forming or maintaining site-linked sargassum citizen science or other types of engagement groups for collaboration and adaptation, including learning networks
- Conducting vulnerability and capacity assessments (VCAs), hazard mapping and the like at all sites at medium to high risk of influx impacts and keep the information at hand
- Ensuring, where insurance is available as a mitigation measure, that premiums are paid up and that the coverage is adequate to cover loss and damage
- Checking that industries and enterprises (household to commercial) that customarily use or want to invest in sargassum as an input are tied into the preparedness and response systems to ensure efficient and effective production processes are on standby
- Identifying routes, areas and people where removal and inland storage of sargassum is likely, so that means of transportation, receiving areas and nearby residents are ready
- Determining trigger points, field protocols, record-keeping and other aspects of the system response that are most critical for consistency and have procedures for each
- Checking that the entire multi-level set of response mechanisms are working adequately, but do not rely entirely on self-assessment, include verification
- Testing, at least quarterly, all or most of these mechanisms via a forum or a simulation so as to reinforce readiness and maintain open communication if sargassum has been scarce

The list of pre-influx actions and operations can be extensive, but it is expected that readiness will be relaxed when there is no imminent threat. The lead agency is responsible for ensuring that readiness can be rapidly ramped up to the appropriate level and scale in a reasonable time.

There are financial and other costs to maintaining readiness and authorities have remarked on their financial constraints. However, if sargassum is integrated into the national to local level multi-hazard early warning systems for hurricane, tsunami, earthquake and other rapid onset events, then sustainability is more likely. The disaster management authority is a critical actor to advise on hazard planning, early warning and responses.

Massive influxes of sargassum are often preceded by smaller strandings. The pre-influx phase practically ends when ‘no action’ is no longer an option. But it is much better to have site-specific action triggers, or indicators, agreed upon beforehand based on the site profile hazard and vulnerability monitoring to brace for impact.

7.2 Influx impact

Although shipping, nautical tourism and pelagic fisheries may experience sargassum impacts far offshore, in areas beyond national jurisdiction (ABNJ or high seas), the geographic areas and distances used to legally define spaces of national influx impact should ideally align with national instruments for

fisheries, marine spatial planning and coastal management. These planning and management boundaries are usually measured in water depth or distance seaward from an agreed shoreline benchmark. For sargassum, distance should be more suitable for public communication purposes, and the following areas with fuzzy boundaries can be considered if there are no other suitable ones already in use:

- Onshore or stranding: from high water mark on beaches or cliffs to the surf zone
- Nearshore or inundation: from the coastal boundary to around one km seaward
- Offshore or influx: from the nearshore boundary to around 20 km (12 miles) seaward

Validating the above categorisation with marine users is important since, just as one needs to consider impact and response sequences over time, one also has to consider sequences over space. In fisheries, for example, offshore influx impact concerns may focus on fishing, but nearshore concerns may be about putting the boat to sea, while on the coast concerns are about health impacts from degrading heaps of sargassum. Similarly, the responses coming landward may be about gear technology, disentangling propellers and responsibly removing a beach stranding respectively. See Vol. 2 Appendices for these and additional considerations.

Impacts and responses have different costs and characteristics by location. All must be planned for as there will be differences due to the size of the sargassum influx (e.g. minor, moderate, massive influx). Several appendices provide guidance for responses depending on the volume and condition of the sargassum. Guidance varies according to the characteristics of the location in the site profile. Evidence based, not arbitrary, judgement and decision-making is critical. Thus, the detailed site profiles must be maintained as up-to-date and accurate as possible. The task of updating site profiles may be best done in collaboration with nearby residents or site users as a citizen science initiative.

Detailed site vulnerability and capacity assessments (VCAs) taking into account physical, ecological and social dimensions inform appropriate actions and operations. Within the umbrella of the SAMS, site-level sargassum management plans may be feasible where local-level coordinated response is feasible. Significant sargassum strandings are less frequent on leeward coasts which are heavily populated and commercialised. But strandings on these coasts of higher economic activity and value may occur when currents reverse or curl around the ends of islands like the gyre or eddy pattern produced by rocks in a swift stream. Strandings on all coasts must be considered, but the threat levels and opportunities for sargassum use differ by site conditions and require regular updating. The use of drones and other technology can be invaluable for updating visible site information efficiently and effectively, including estimating the volume of strandings[17]. UAS could expedite critical decisions on whether beaches fall within category 4 or 5, signalling cleaning by heavy machinery.

Vol. 2 Appendices contain profiles and maps of locations where strandings are common, as expected mainly on the east and southeast coasts. They show physical, ecological and limited social features. A threat ranking system, commonly used for many types of hazards, is recommended based on national practices. Site profiles are to be refined by the time series of monitoring observations and data on all site characteristics. Some changes in marine biodiversity (e.g. seagrass beds, fringing reefs) or profiles of nearby communities (e.g. proximity to coast, number of asthmatics) for example, can alter threat assessments and inform appropriate response. It is good that manual sargassum removal often prevails.

Critical components of impact influx include all those listed as examples for pre-influx plus these (and see Vol. 2 Appendices):

- Using the agreed pre-influx systems and protocols (e.g. developed under the SargAdapt project) for actions and operations rather than *ad hoc* and reactive responses, the exceptions being new responsible innovations for addressing threats and opportunities that need to be tested for learning and adaptation
- Matching influx or inundation characteristics to the response, including harvesting or removal
- Deploying the correct equipment and personnel for the selected site and time specific response
- Collecting the agreed sargassum statistics meticulously with metadata to preserve time series
- Maintaining monitoring and evaluation for learning and adaptation as a priority rather than secondary option, especially when and where new rapid responses are required
- Prioritising the health and well-being of people (field staff, nearby residents, users) and the environment (marine, coastal, terrestrial) while managing trade-offs between them
- Checking that both equipment and personnel are well seen after following each site activity
- Exchanging information, in as close to real time as possible, data and information with the established sargassum networks in order to contribute to, and be informed by, the responses and uses in other places for mutual knowledge and financial benefits
- Supporting accurate and informative news media reports, including on social media, to improve transparency and reduce misinformation as a component of engagement
- Ensuring that the learning network established pre-influx is working well and that lessons are communicated for decision-makers as well as the general public to be informed
- Paying special attention to new or emerging vulnerabilities (ecological and social) that require shifts in action or longer-term adaptive capacity in order to build resilience

The list for influx impact is intentionally short as the focus should primarily be on implementing, monitoring and learning from what was set up pre-influx. While experimentation in impacts will be necessary, doing so must still be well thought out rather than impulsive and reactive. It is possible to make good decisions quickly if the decision-makers are well-informed beforehand and well versed in making evidence-based or influenced decisions through prior experience.

7.3 Post-influx

This last phase, like the first, assumes that the influx impacts of sargassum are seasonal or intermittent (i.e. acute), even if somewhat prolonged, but not continuous (i.e. chronic). After an influx of fresh sargassum the seaweed and its degradation products may persist for months in the marine environment or ashore. As with impact, the variables influencing the consequences of this are many and interact in complex ways that shape the temporal and spatial extent of vulnerability as well as opportunities for sargassum use. Although uses are included in impact, especially if prolonged, in most situations they will be most important post-influx. Some uses are traditional or evolving (e.g. solid and liquid fertiliser) but many are now emerging (e.g. chemical extraction, bio-energy) as set out in the sargassum uses guide previously referenced. Sargassum uses and innovations contribute to 'blue growth' and should be integrated within the forthcoming blue economy road map. The entire blue economy relationship with sargassum must be kept under constant review and update.

Emerging commercial uses of sargassum are as dynamic as the science, hence requiring constant updating of useful links and resources such as on a dedicated website. Uses (and also simply disposal) will have different life cycles that determine the suitability of the different species and strains of

sargassum as well as the condition of the sargassum input. For example, fresh wet sargassum is heavier, handles differently and has different chemical and ecological composition compared to degraded sargassum whether dry ashore or wet in the nearshore. Sharing information on the practical characteristics of sargassum is as critical as the science.

Large quantities of sargassum remaining stagnant in shallow, sheltered bays with sandy beaches that are near communities or tourism infrastructure are of particular post-influx concern for many reasons. Extended social and ecological impacts are inevitable. The critical components of the previous two phases still apply, but the following deserve special attention (see Vol. 2 Appendices):

- Maintaining enabling policy and economic environments to support gender sensitive innovation and entrepreneurship for sargassum uses including credit, venture capital, research services and other facilities especially for small and medium scale enterprises
- Linking users with sources of science and technology to keep them well informed
- Assisting in market studies and creation of new markets for novel products, particularly those with high domestic value-added contributions that support local livelihoods
- Adjusting social security nets and local governance to address site-specific recovery
- Encouraging large private sector companies, investors and financial institutions to play active roles in sargassum entrepreneurship in periods between influxes with adequate provisions for risk management due to unpredictability and several other uncertainties
- Retaining the interest in sargassum as part of the national climate change and justice processes in order to keep or elevate attention on the world stage as a SIDS issue
- Sustaining learning, adaptation and readiness that transitions into the pre-influx phase

In many cases the post-influx phase may be short and virtually indistinguishable from pre-influx. However, the main distinction must be the opportunity to learn and adapt so the systems can be adjusted in pre-influx prior to the next influx impact. Reacting more than is essential during impact or immediate post-impact is not recommended. Good planning and management will often be compromised by the urgency to “do something”.

Three critical questions for authorities to answer in the SAMS approval process:
Are most of the sargassum actions and operations used in well-established approaches?
Are the sargassum action and operation arrangements feasible for participatory MEL?
Is there a strong enough organisational and societal culture to sustain adaptive practices?

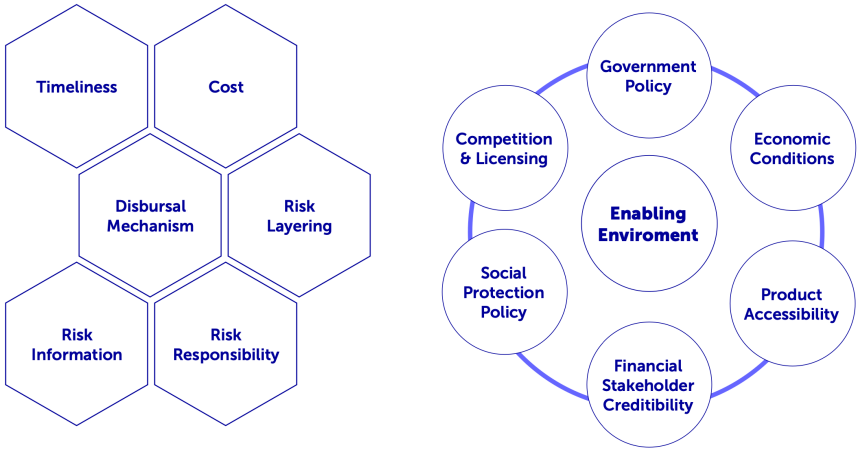
8 Monetary matters

Monitoring and measuring sargassum; mobilising knowledge to share; responding to inundation by nearshore harvesting, beach clean-ups and other means all have costs e.g. salaries and wages, equipment, etc. There are also costs to taking no action e.g. loss of earnings, public health risks, biodiversity loss, etc. Some of these costs are direct and borne by clearly identified actors e.g. affected businesses, coastal residents and users, etc. Others are indirect social costs borne by society at large or in-kind costs shared by several actors each contributing a little e.g., via community organisation and researcher volunteer time. Finally, and critically important, is building the benefits and revenues from sargassum via enterprises and uses that generate value and income such as from manufacturing goods,

producing energy, enhancing ecosystem services, etc[18]. We look briefly at financial aspects of sargassum, as hazard and as opportunity which also have scientific and technical considerations (Vol 2 Appendices).

8.1 Hazard

Governments should already have in place comprehensive and transparent intersectoral DRM plans that include climate and disaster risk financing (CDRF). Sargassum in massive quantities is a natural hazard, and hence should be included in such plans. Besides pure finance, DRM plans must also integrate risk assessment, institutional capacity building, risk reduction and mitigation and emergency preparedness on a long-term climate risk time scale to provide adequate resources for adaptation. All apply to sargassum. A selection of CDRF design and implementation considerations as well as its enabling environment are illustrated in Figure 13. While these are not specific to sargassum, there may be challenges to incorporate the seaweed into established portfolios and budgets. Data and information are required to assess sargassum risks.



(a) CDRF considerations (b) CDRF enabling environment

Figure 13. Climate and Disaster Risk Financing (CDRF) considerations and enabling environment[19]

The state creates an enabling environment for CDRF at all levels of governance by coordinating vertically and across ministerial mandates, with the private sector, with communities and civil society organisations. Given that non-state actors and small businesses are typically reliant on informal financial mechanisms to manage risk, a functional enabling environment is critical to building financial resilience to sargassum. To count the costs of responding to sargassum, or even of taking no action, methods similar to damage and loss in DRM can be used. The financial strategy must seek to contain costs within levels that should have been previously estimated in risk assessment. Data collection, at its most basic, should include costs of:

- Labour, equipment, energy, transport, etc.
- More rapid depreciation of equipment
- In-kind contributions of supporters, etc.
- Reduced use of coast and storage areas
- Information and communication at all stages
- Coordination and collaboration among actors
- Loss of biodiversity and ecosystem services
- Physical damage to items or reduction in value

Data with which to compute costs must be systematically and consistently collected. Some private sector firms and local communities are active in clean-up operations, so their real and in-kind costs must be fully counted. As with protocols for the estimation of sargassum volumes on beaches, financial

estimates can be calculated via sampling and scaling up. Statistics for sargassum and financing should be determined by the types of decisions to be made, and calculations automated as much as possible, similar to the ecological parameters. Sargassum response budgets should be allocated to cover recurrent costs and maintenance. Variable costs can be more discretionary, with clear mechanisms for triggering disbursements to fit demands. Parametric insurance against sargassum risks should become more widely available in the future.

Long term costs of sargassum such as loss of some ecosystem services, and possible public health issues, will require time series from monitoring, so metadata need to be maintained in order to track methods of measurement. The cost of sustaining the information system is therefore also a consideration. Ecological and resource economics are needed to estimate intangible or non-market values such as decisions of tourists to avoid a destination due to actual or perceived threats of negative sargassum experiences. Costs of not taking action should also be quantified, and opportunities cannot be ignored.

8.2 Opportunity

Cost-offsetting or cost recovery and opportunities for genuine income generation by new sargassum-based industries must be relentlessly pursued. Sargassum use in plant growth products, renewable energy and construction materials is becoming better established. These will neither absorb huge influxes nor spread the socio-economic benefits of sargassum throughout societies, but they can make good use of the natural resource. Regionally, many potential uses of sargassum are not yet appropriately regulated regarding product safety standards. Potential public health consequences are a concern. High levels of inorganic arsenic and some heavy metals in sargassum are top among current concerns. Sargassum is being used as a fertiliser in on a small scale in some islands.

Financing for research, development and commercialisation of sargassum value-added products is very scarce in insular Caribbean countries as new ventures are considered high risk, costly, or both. Countries should examine available financial tools and options to support innovation and entrepreneurship, without compromising the due diligence required to ensure that the undertakings are acceptable. Tools include:

- Research and development grants
- Venture capitalists and angel investors
- Corporate and personal income tax relief
- Crowdfunding initiatives of various types
- External investor or state joint ventures
- Low interest commercial loans
- Accelerator labs and incubators
- Tax credits for R&D investments
- Blue carbon credit markets, bonds
- Pilot and demonstration projects

State agencies leading SAMS should have access to information on the financial aspects of opportunities in order to align responses to better serve the highest value feasible, e.g. sargassum collection methods and storage conditions that provide the best raw material. There is growing consensus in the valorisation of sargassum that the seaweed should be intercepted offshore to reduce ecological, economic and social issues it causes onshore, while harvesting it in the fresh form most useful in many cases for value-added processing (Figure 14). There are several challenges to doing so, however, as shown in the literature with some guidance in the Vol. 2 Appendices[20].

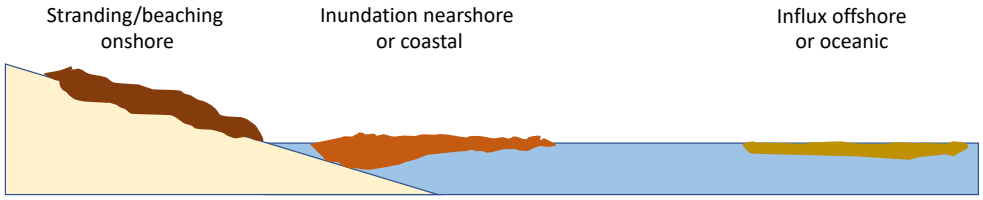


Figure 14. Sargassum should ideally be harvested offshore, before inundation and stranding issues accumulate

A sargassum uses guide[21] (Figure 15) contains information on innovation and many opportunities for budding sargassum entrepreneurs, of which there are several emerging regionally among young women and young men. A persistent challenge is the need for small to micro-enterprise development to be properly informed by scientific research to make good and safe decisions for commercialisation as warned above. These communication costs are not trivial, whether public or private, and financial institutions will also need guidance on addressing the financial risks of various technologies.

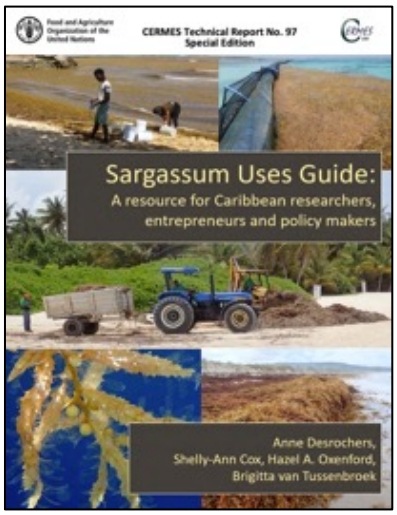


Figure 15. Sargassum Uses Guide presents many opportunities for informed innovation and entrepreneurship (Source: Desrochers et al. 2020 and presentations)

Overall, a SAMS aims for the responsible removal of large amounts of seaweed to be made economically viable through local use while distributing the profits across firms linked to the blue economy. Information on earnings, or sargassum benefits more generally, is scarce especially at a national level in the absence of green accounting. It is beyond the scope of this draft SAMS to provide more detailed recommendations on the economic and financial aspects of sargassum in the context of blue economic development. Vol 2 Appendices ensure that these aspects are not overlooked. Actions and operations are in the next section.

Three critical questions for authorities to answer in the SAMS approval process:
Is sargassum hazard early warning and response systems using established DRM practices?
Are sargassum opportunities likely to be taken advantage of by innovators and entrepreneurs?

Does the official accounting system adequately allow for the valuation of ecosystem services?

9 Further action

An approved sargassum adaptive management strategy (SAMS) will never be final in the sense of being shelved for use simply as a reference document. It must remain a dynamic, primarily electronic, document updated regularly and preferably maintained as a series of web pages with the most current data and information. Participatory geographic information system (PGIS) data with a citizen science component will be useful to engage a critical mass of island-wide collaborators. Consider the three-input process (Figure 16).

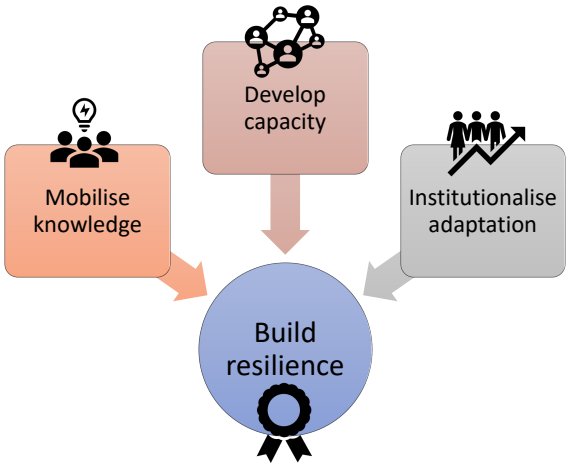


Figure 16. A three-step process for building resilience

For each of the inputs, the types of additional data, information systems, adaptive capacity development, collaborative planning, decision-making, social learning, institutional arrangements, etc. that could be employed are many (see Vol. 2 Appendices). The 3rd UWI Sargassum Symposium in March 2023 was a reminder that, the more we discover about sargassum and how to manage it, we are learning how much more there is still to learn. The primary outcome is, however, to build societal social-ecological resilience in an iterative fashion through which the inputs are repeated in cycles of progress that keep pace with the changing climate and other conditions affecting both sargassum influxes and social-ecological situations.

We, again, strongly encourage the formal approval of a SAMS using this updated draft as a starting point and tailoring content to reflect the current and expected conditions with up to about a five-year planning horizon for Vol. 1 and a short-term (e.g. quarterly) updating cycle for Vol. 2 Appendices (Figure 17).

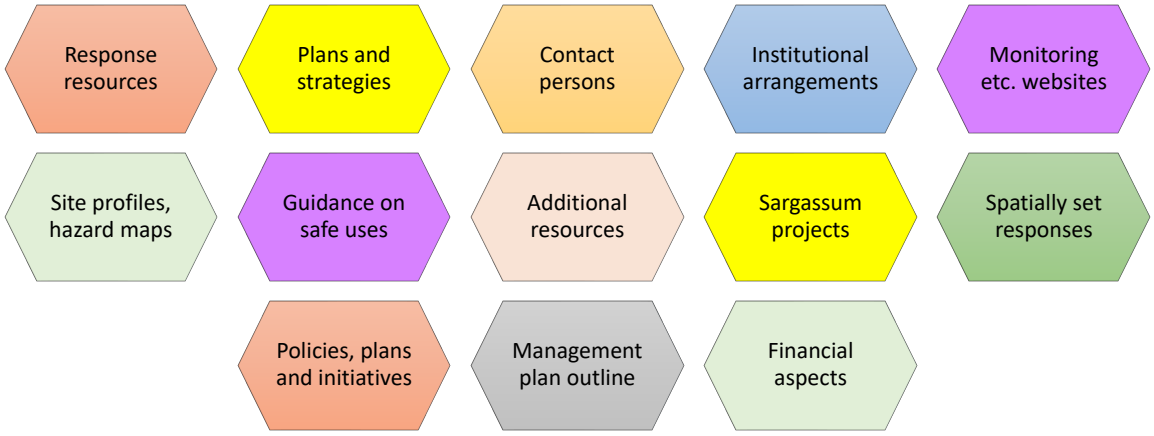


Figure 17. Some of the action appendices in Volume 2

10 Notes and references

[1] While acknowledging that formally "Virgin Islands" is correct without a qualifier, the SAMS adds British and uses the acronym BVI to avoid any confusion among readers with the United States Virgin Islands
[2] SargAdapt project web page. https://www.cavehill.uwi.edu/cermes/projects/sargassum/sargadapt.aspx
[3] All three UWI-CERMES sargassum symposia can be accessed via this web page. https://www.cavehill.uwi.edu/cermes/projects/sargassum/symposia.aspx
[4] Refer to … CANARI 2011. Facilitating participatory natural resource management: A toolkit for Caribbean managers. Laventille: CANARI. [http://www.canari.org/publications.asp]
[5] See for Montserrat: Mendes, S., 2021. Sustainable Sargassum Management: Montserrat. Presentation at the Virtual Launch of the Sustainable Sargassum Management in Anguilla, British Virgin Islands and Montserrat Project, December 1, 2021.
[6] E.g. CANARI. 2021.Communications Plan for Barbados (Conset Bay and Oistins). SargAdapt Project.
[7] We refer generically to sargassum authority or authorities as few countries have maintained consistent institutional arrangements for sargassum management and often there is no leading authority in practice
[8] Also see for Montserrat: [1] Dickie, I, Yague Garcia, P. Middleton, A. & Baruah, L. 2019a. A National Ecosystem Assessment of the UK Overseas Territory of Montserrat: Natural capital assessments, mapping and monitoring methods – Phase II. Final Report. Contracted report to JNCC.
[2] Dickie, I, Yague Garcia, P. Middleton, A. & Baruah, L. 2019b. A National Ecosystem Assessment of the UK Overseas Territory of Montserrat: natural capital assessments, mapping and monitoring methods. Natural Capital in the UK's Overseas Territories Report Series – Supplementary Report (Caribbean Region). Contracted report to JNCC.
[9] CERMES and CANARI convened a regional sargassum action learning network under SargAdapt
[10] Visit Caribbean Disaster Emergency Management Agency (CDEMA) website https://www.cdema.org/
[11] Also see for Montserrat: [1] Granderson, A., Ramkissoon, C., Jehu, A. & Phillips, T. 2018. Report on the assessment of vulnerability to climate change in the Anguilla and Montserrat fisheries sectors. Port of Spain: CANARI. [2] CANARI. 2017. Report of the Inception Workshop for the Project Steering Committee and Other Key Stakeholders. Held as part of the Climate change adaptation in the fisheries of Anguilla and Montserrat project. August 30-31, 2017. Montserrat.
[12] Visit Caribbean Community Climate Change Centre (CCCCC) website https://www.caribbeanclimate.bz/
[13] Compton, S., P. McConney, I. Monnereau, B. Simmons and R. Mahon. 2020. Good practice guidelines for successful National Intersectoral Coordination Mechanisms (NICs): Second Edition. Report for the

UNDP/GEF CLME+ Project (2015-2020). CERMES Technical Report. No. 88 https://www.cavehill.uwi.edu/cermes/docs/technical_reports/compton_et_al_2020_nic_guidelines_ctr_88_2nd.aspx

[14] Also see for Montserrat: [1] Environmental Law Institute. 2015. Sustainable Fisheries and Coastal Zoning in Montserrat.
[2] Flower, J., Ramdeen, R., Estep, A., Thomas, L.R., Francis, S., Goldberg, G., Johnson, A.E., McClintock, W., Mendes, S.R., Mengerink, K. and O'Garro, M., 2020. Marine spatial planning on the Caribbean island of Montserrat: Lessons for data-limited small islands. Conservation Science and Practice, 2(4):158.

[15] Sub-regional Sargassum Outlook Bulletin https://www.cavehill.uwi.edu/cermes/projects/sargassum/outlook-bulletin.aspx

[16] Download Baldwin, K., P. McConney and R. Sandoval. 2021. An introduction to using drones for participatory mapping of climate, poverty and fisheries information in Caribbean coastal communities. Centre for Resource Management and Environmental Studies, University of the West Indies, Barbados. CERMES Technical Report No. 104. from https://www.cavehill.uwi.edu/cermes/docs/technical_reports/

[17] For more information see https://www.cavehill.uwi.edu/cermes/projects/sargassum/research.aspx

[18] Also see for Montserrat: Sustainable Fisheries Group. 2015. A Review of the Ecology and Economics of Montserrat's Marine Resources, University of California - Santa Barbara

[19] UNU-EHS 2021 Climate and Disaster Risk Financing Instruments: An Overview. United Nations University Institute for Environment and Human Security (UNU-EHS)

[20] The CERMES Sargassum Reference Repository provides a great supplement of more literature for the appendices. Visit https://www.cavehill.uwi.edu/cermes/projects/sargassum/reference-repository.aspx

[21] See Desrochers, A., S-A. Cox, H.A. Oxenford and B. van Tussenbroek. 2020. Sargassum uses guide: a resource for Caribbean researchers, entrepreneurs and policy makers. Report funded by and prepared for the CC4FISH Project of the FAO. CERMES Technical Report No 97. 172 pp from https://www.cavehill.uwi.edu/cermes/projects/sargassum/docs/desrochers_et_al_2020_sargassum_uses_guide_advance.aspx