Opportunities for valorisation of pelagic *Sargassum* in the Dutch Caribbean

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- TKI 1 year project (jan-dec 2020)
- Goals of the study
 - Review the state-of-the-art on *Sargassum* biology and value chains for valorisation
 - Identify knowledge gaps and define a research agenda to support implementation of valorisation chains in Dutch Caribbean
- 1. Biology, ecology, origin, socio-ecological impact and management (Matthijs van der Geest, WMR)
- 2. Valorisation options (Ana Lopez Contreras, WFBR)
- 3. Economic, societal and environmental impact of value chains (Sander van den Burg, WEcR)

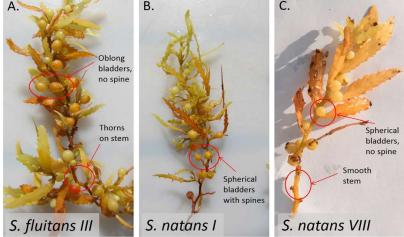
4. Research agenda (KG), 5. Implementation plan, 6. General conclusions

1.1 Biology and ecology of pelagic Sargassum

- Sargassum: a genus of brown macroalgae with >350 species in both temperate and tropical oceans, mostly benthic (bottom-attached)
- A few species, restricted to the Atlantic Ocean, are "holopelagic" spending their full life cycle afloat, transported by ocean currents with influence from surface winds







(Govindarajan et al., 2019)

1.1 Biology and ecology of pelagic Sargassum

- Vegetative reproduction through growth and fragmentation
- Rapid growth when conditions are favorable (doubling time: 9-14 days)
- Formation of extensive floating rafts in otherwise empty ocean



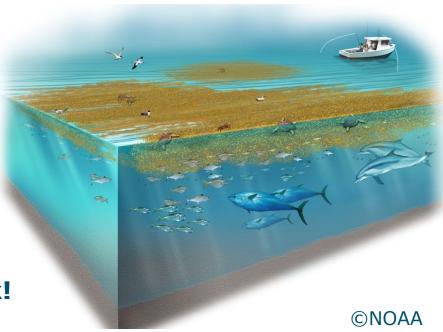


1.1 Biology and ecology of pelagic Sargassum

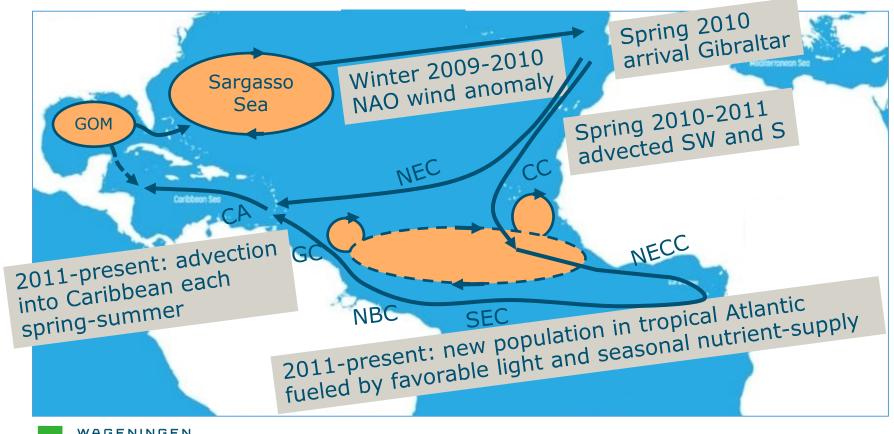
- Sargassum rafts provide a critical spawning, nursery and foraging habitat for many (endangered) species, some of which are endemic
- 145 invertebrate species
- 111 fish species
- 26 seabird species
- 4 sea turtle species
- Dolphins







1.2 Origin pelagic Sargassum influxes Caribbean



1.3 Impacts pelagic *Sargassum* influxes Caribbean

When beaching socio-ecological impact on:

- Coastal habitats and fauna
- Tourist industry
- Human health
- Fisheries (indirect and direct)

Cleaning of 1m² coastline: ~1000 USD





1.4 Management of pelagic Sargassum influxes

Current situation Dutch Caribbean

- Insufficient material for prevention
- Damage to coastal habitats
- Beach clean-ups labor-intensive with risk to human health and environmental damage
- Often no management plan/policies for disposal and storage of *Sargassum*





1.4 Management of pelagic *Sargassum* influxes

An environmental trade-off: harvesting at sea of let it beach?

Harvesting:	On-shore	Near-shore	Off-shore
Environmental impact	high	low	high
Suitable for processing	-	+	+
Technical & economic feasibility	+/-	+	-

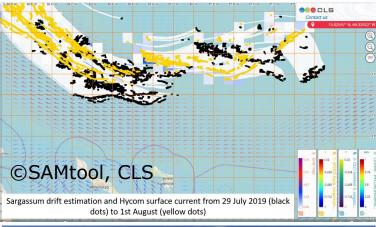
Prevent Sargassum from beaching: harvest near-shore!



1.4 Management of pelagic Sargassum influxes

- Early warning systems based on RS: 4-day stranding forecasts
- Easily deployed, cleanable, robust
 booms to prevent beaching and direct
 Sargassum to suitable sites for harvest
- Multicat that can harvest and process
 Sargassum near-shore
- Sustainable valorisation chain for harvested Sargassum







2. Valorisation Options

- Sargassum is mainly composed of sugars (polymers, mannitol), uronic ac. (alginic ac.), salts, protein, lipids
- Relative composition varies with growth conditions
- Contains bioactive compounds: fucoidans, other
- Wide range of uses: from fertilizer to building material
- Content in heavy metals, iodine and arsenic can limit applications in food chain





Composition of pelagic *Sargassum* samples

	% of dry weight			mg/kg			
Samples Bonaire	Sugars*	Uronic ac	Ash**	Protein	I	tAs	iAs
Lagun	14.1	13.5	42.5	6.2	221	89	56
Lac Bay	12.1	12.9	47.5	5.8	403	74	44

*Glucose, xylose, fucose. Mannitol detected in Lac Bay sample, 0.7%

****** K, Ca, Na, S most abundant

For use as organic fertilizer: iAs max. content is 40 mg/kg For use as feed: iAs max. content 2 mg/mg

Iodine is at relatively high levels for direct applications on food/feed









Lagun sample

Lac Bay sample

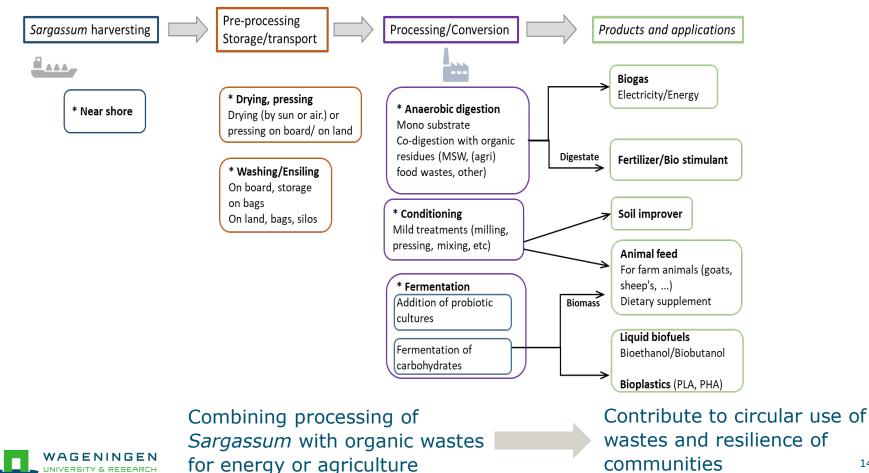
Collected by Sabine Engel

Value chains for valorisation

- Sargassum blooms are seasonal and difficult to predict in the long term
- For a Sargassum-based valorisation chain, reliable and sustainable supply is necessary: Farms could be an option, not established yet
- For the current situation in Dutch Caribbean: Prevent disposal and combine the processing of *Sargassum* with other organic wastes (food waste, manure, garden waste,..) in the islands, contributing to a circular use of biomasses
- Need for scalable and continuous systems to process the biomass of blooms as needed



Valorisation chains



14

3. Economic, societal and environmental impact of valorisation chains

Based on literature: a general feeling that pelagic *Sargassum* is a costly problem but no detailed analysis.

Step one: Getting to grips with the problem:

- Stakeholder analysis, incl. who bears current costs
- Analysis of direct economic impact
- Analysis of indirect economic impact



https://caribischnetwerk.ntr.nl/2018/03/07/iedereen-doet-wat-hij-kan-tegen-sargassum-op-bonaire/



Impact

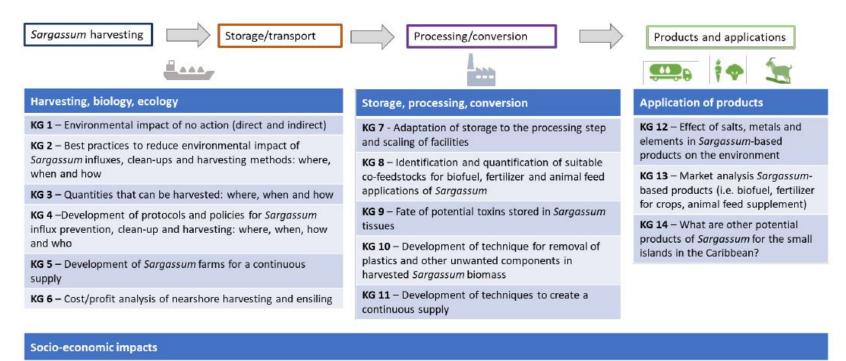
Second step: analysis of costs and benefits of valorisation options

- Which activities/valorisation options are the most promising?
- Evaluation of environmental and climate impact using LCA and Carbon Footprint methods
- Who wants to invest in decreasing the impact of the pelagic Sargassum blooms?

-> multiple methodological suggestions are in our report



4. Knowledge gaps



- KG 15 Socio-economic costs of no action (direct and indirect)
- KG 16 Identification of stakeholders relevant for Sargassum harvesting, processing and commercialization of products
- KG 17 Socio-economic effects of the Sargassum based innovations: employment, infrastructures, etc
- KG 18 Supplementary local data to optimize the Value Chain Analysis
- KG 19 Replacement effects (e.g. reducing the need for imports of fossil fuels, fertilizers and animal feed, improvement of resource security)

5. Implementation plan

	Phase 1	Phase 2	Phase 3
Environmental	 Collect regional data on amount of (harvestable) Sargassum (S) biomass in time and space (KG 1-3) Study effect of beaching and off-, near- and onshore S harvesting methods (KG 3) on biodiversity and key marine habitats Determine fate of S leachates into soil and coastal waters (KG 9, KG 10) 	 Select system for prevention of beaching (when, where, how, who) and harvesting of S influxes and do pilot studies to monitor its efficiency and sustainability (KG 4) 	 Evaluation of continuous S supply, possibilities, including long-term storage or S farms (KG 5, KG 11)
Processing and valorization	 Storage and logistics plan for S biomass (KG 7, KG 10) Determine availability of organic streams as co-feedstock for anaerobic digestion (AD) of S (KG 8) Pilot tests for use of S for AD and as animal feed supplement for goats and chicken (KG 7, KG 8) 	 Pilot tests for AD and animal feed with S and mixtures of biomasses (KG 8-9, KG 12-13,, KG 17-19)) Investigate uses of the methane produced in Islands (KG 8) Potentials uses of S and/or digestate in agriculture (e.g. fertilizer for crops) (KG 8, KG 9) 	 Pilot tests on selected options from Phase 2 Investigate other products with high added value (KG 13, KG 14) Investigate liquid biofuel production for transport (KG 13, KG 14)
Societal Techno- Economic Life Cycle Assess- ment (LCA)	 Calculate costs of non-action/current approaches (LCA) (KG 15, KG 16) Local needs in terms of biofuel and agricultural products (KG 16) Identify and involve stakeholders, including general public (KG 16, KG 17) 	 Continuation of Phase 1 analysis Compilation and analysis of data from the activities on Environmental and Processing and valorization themes (KG 4) Policy development for <i>S</i> actions (KGs 17-19) 	 Socio-economic effect of new S value chains on islands communities (KGs 15-17) Replacement effects (e.g. reducing the need for imports of fossil fuels, fertilizers and animal feed, improvement of resource security) (KG 19) Market studies for interesting products (KG 19)

6. General conclusions

- Pelagic Sargassum provides vital ecosystem services at open ocean
- Pelagic Sargassum influxes and blooms in Caribbean likely to persist
- Influxes are a global problem that requires international cooperation
- To reduce socio-ecological impact of influxes best to prevent beaching
- Near shore harvesting most environmentally friendly
- Development of Sargassum management & valorisation policies needed
- Need for quantification of harvestable biomass in Dutch Caribbean to make appropriate business plan for valorisation



- Mapping and quantification of biomasses that can be co-processed with pelagic Sargassum for anaerobic digestion-based value chains
- Develop island specific Sargassum-based value chains
- Evaluate potential risks of where and how toxic compounds in pelagic Sargassum may accumulate in the value chain, including leaching in soil
- Evaluate social (job-creation) aspects of pelagic Sargassum management and valorisation and how it affects the communities involved



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Report available at: https://library.wur.nl/WebQuery/wurpubs/fulltext/543797

