i. **Title:** *Large scale seaweed aquaculture for CO_2 remediation*

ii. **Context and rationale**.

According to the UN's FAO, present mariculture production of seaweeds is about 30 million tons annually. While 99.9 % of this production takes place in Asia, several reports and papers indicate a great potential for cultivation of marine seaweed biomass globally, at 10^9 to 10^{11} tons dry weight per year. At a low carbon content of 20 % of the dry weight, this amounts to a net potential CO_2 turnover of 0.73 to 73 gigatons (10^9 tons) per year. The seaweed cultivation potential seems to be large in tropical, temperate and sub-arctic regions alike, thus providing an opportunity for a geographically balanced biomass production.

iii. An overview of the contribution.

The contribution aims to promote science-based large-scale commercial seaweed mariculture.

iv. How the contribution leverages living natural systems as a solution to avert climate change?

The contribution is based on marine primary production. Though not a natural system *per se*, seaweed aquaculture extracts dissolved nutrients and interacts potentially beneficially with the marine ecosystem, providing a substrate for other marine organisms. Nutrient extraction may counterbalance local and regional eutrophication in coastal regions. Seaweeds generally require less nitrogen and phosphorous per unit carbon photosynthesized than microalgae. Kelp and other seaweed communities are in decline globally, and the promotion of seaweed aquaculture may counteract this by using autochthonous species.

v. How might the contribution support both climate, mitigation and adaptation as well as other important co-benefits and social, economic and environmental outcomes in coming years including:

a. Reduction in carbon emission and carbon capture (GTonnes)

Seaweed biomass is already used most notably in the food processing industries (carrageenans, alginate). Research initiatives financed by national (e.g. Norway) and international (the European Commission, GENIALG) bodies focusing on biorefinery techniques for cultivated seaweed biomass herald a potential for reducing CO_2 emissions by processing products based on renewable primary production. Producing biofuels from seaweeds reduces the need for fossil fuels, reducing the emissions. Using locally produced seaweed biomass in fish feed formulation reduces the need for long distance transport (cf Brazilian soy in Atlantic salmon feed in Northern Europe).

Natural seaweed communities export organic carbon to deep waters and sedimentation through the release of (dissolved) polyphenols and polysaccharides and particulate organic matter through the continuous "peeling off" of tissue. This has hitherto not been considered explicitly in "blue carbon" budgets. Cultivated seaweeds similarly release carbon-rich matter in both dissolved and particulate form. Off-shore seaweed farms may be located in regions of great bottom depth, with a potential for sinking out and subsequent sedimentation of the lost and excreted biomass. Deliberate deposition of the seaweed biomass in these deep regions has a great potential for carbon capture

Examples from the North Eastern Atlantic (Norwegian sea) indicate a potential net uptake of CO_2 of > 2500 t per km^2 seaweed (kelp) farm in offshore regions.

b. Increasing climate resilience

The contribution will increase climate resilience for the aquaculture industry, in particular in the Western Hemisphere, through diversification. Seaweed mariculture will contribute to offsetting the effects of local, regional and global climate change on agriculture through food production in different seasonal cycles.

c. Social impact (job increase; poverty reduction, etc.)

Seaweed mariculture has significantly improved the livelihoods in remote parts of Indonesia and entails opportunities globally, e.g. by job security through diversification in existing mariculture communities There are further possibilities in terms of local processing of the biomass, depending on the targeted end product.

d. Net economic impact (total in US$; how was it achieved?)

Reports indicate a potential annual turnover of the industry based on cultivated seaweeds in Norway alone of 4.57 million USD, based on the present (2012) turnover of the Asian seaweed market, the historic development of the Norwegian aquaculture industry, and on prospects and prices of a wide array of compounds that may be extracted from seaweed biomass through bio refinery techniques. Technology to enable cultivation at a price of max 20 Euro per ton wet weight is crucial.

e. Impact on realization of the 2030 Agenda for Sustainable Development (in particular SDGs 1,2,6,12,13,14,15,16)

The action will contribute to reducing poverty (SDG1), increasing food production (SDG2), reduce fresh water use in bioproduction (SDG6), focusing on primary production (SDG 12), climate action (potentially reducing emissions and capturing CO_2) (SDG 13) and will provide ecosystem services for arange of species (SDG14).

f. Just transition

The initiative will link to the ASC MSC Seaweed Standard, involving metrics for e.g. working conditions. A global partnership for seaweed mariculture will be established. Global perspectives permeate the contribution. See **xiii** below.

g. Food security

Global cultivation of seaweeds provides a new, global resource that may be harvested all year round in different regions from the tropical to the polar regions, hence contributing to global food security.

h. Minimising species extinction and ecological losses and fostering an increase of biodiversity.

Seaweed farms supply some of the same ecosystem services as natural seaweed communities. Cultivating autochthonous species and using several species will promote biodiversity associated with the farms and contribute towards maintaining biodiversity. Further, seaweed farming does not require use of pesticides or fertilizers (e.g. phosphorus) or compete for arable land and freshwater resources.

vi. Which countries and organisations are involved in the contribution?

Norway. SINTEF Ocean.

vii. How have stakeholders (for example indigenous peoples, local communities, and youth) been consulted in developing the contribution?

This is development on an early stage in the Western Hemisphere. Local communities in Northern Europe are looking to seaweed mariculture as a major emerging possibility, both as a livelihood and as a tool to improve the environmental status of the sea, as well as counteracting climate change.

viii. Where the contribution can be put into action?

The contribution can be implemented in all coastal and ocean regions where seaweed aquaculture is feasible.

ix. How the contribution will be delivered? How will different stakeholders be engaged in its implementation? What are the potential transformational impacts?

The contribution will be delivered as a **seamap to industrial seaweed mariculture** describing the needs for implementing new technologies, new policies and new mind sets. Stakeholders from science, governance, industry, trade and the general public will be involved. Potential transformational impacts involve developing a new mind set where stakeholders are more aware of how the marine ecosystem works than today.

x. **Is this initiative contributing to other Climate Action Summit workstream (industry transition; energy transition; climate finance and carbon pricing; infrastructure, cities and local action; resilience and adaptation; youth and citizen mobilization; social and political drivers; mitigation strategy)?**

Yes: resilience and adaption, industry transition, mitigation. Possible re-use of decommissioned oil platforms, co-use of areas with ocean wind farms.

xi. **Examples of experiences to date: how does this contribution build upon this experience? How does the contribution link with different ongoing initiatives?**

The contribution links with several ongoing research initiatives financed by both national and international funding bodies (industry, national research councils, the EC).

xii. **Mechanisms for funding (with specific emphasis on potential for partnerships).**

Not relevant/unknown.

xiii. **Means of stewardship, metrics for monitoring.**

The initiative involves fostering a global partnership for seaweed mariculture link this partnership to the ASC MSC Seaweed Standard (https://www.asc-aqua.org/what-we-do/our-standards/seaweed-standard/) with a particular emphasis on carbon turnover and capture.

xiv. **Communication strategy***.*

Communication between farmers and stakeholders within the global partnership will be given attention on par with communication to politicians and the general public. Communication technologies will involve platforms accessible by smartphones for efficient diffusion of information.

xv. **Contact details of proponents (indicating the degree of commitment among the countries and organizations that are named).**

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