SUPPLEMENTARY INFORMATION

Questions raised by sinking seaweed: A Life Cycle Assessment of Macroalgae Cultivation and Sinking for Carbon Dioxide Removal

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S.2 Modelling MCS transportation to deposition site

Table S2. Overview of European S. Latissima cultivation sites reported in literature, their estimated transportation distances to deep-sea deposition sites (> 1 000 m depth), and the average distance adopted as the transportation distance in the base-case MCS model.

Location	**Distance to deposition site (NOAA, n.d.)**	**Deposition location (European Marine Observation and Data Network, n.d.)**
Blackson Bay, Ireland (Nilsson et al., 2022) 54.083322, -10.016828*	104 km	54°20'35.8"N 11°33'07.8"W (54.343290, -11.552160)
Solund, Norway (Philis et al., 2018; Kroesling et al., 2021) 61.109416, 4.540340	272 km	62°45'11.1"N 0°41'39.2"E (62.753080, 0.694230)
Koster archipelago, Sweden (Thomas et al., 2020) 58.896702, 10.993236	695 km	62°51'34.0"N 1°00'40.2"E (62.859440, 1.011170)
Hjarnø, Denmark (Zhang et al., 2022) 55.820158, 10.101635	935 km	62°51'34.0"N 1°00'40.2"E (62.859440, 1.011170)
Grenaa, Denmark (Zhang et al., 2022) 56.404229, 10.940088	907 km	62°51'34.0"N 1°00'40.2"E (62.859440, 1.011170)
Limfjorden, Denmark (Zhang et al., 2022) 56.887629, 8.950930	805 km	61°51'17.4"N 1°26'46.9"W (61.854820, -1.446350)
Ventry Harbour, Ireland (Taelman et al., 2015) 52.121533, -10.355409	138 km	51°52'47.8"N 12°20'05.1"W (51.879930, -12.334750)
Sistranda, Norway (Ayala et al., 2023) 63.771803, 8.325398	379 km	63°39'10.3"N 5°16'59.8"E (63.652850, 5.283270)
The Hague, The Netherlands (Slegers et al., 2021) 52.102107, 4.214580	1 007 km	47°51'46.0"N 8°16'28.5"W (47.862770, -8.274580)
Average distance to deposition site	**582.4km**	

*Although the cultivation sites were identified from the corresponding studies, their exact geographical coordinates were estimated for the purpose of calculating transportation distances. Similarly, the deposition site coordinates were assumed and do not represent actual or operational deposition sites. Instead, they were selected as representative estimates of the nearest offshore locations with water depths exceeding 1 000 m.

S.3 Sensitivity analysis parameter rationales

Table S3: Rationale for the selection of parameters included in the sensitivity analysis. The table summarises the relevance of each parameter to the environmental performance of MCS, associated sources of variability and uncertainty, and motivation for their inclusion in the assessment.

Parameter	Narrative/description
Parameters of interest (discrete)	
Time (present-day vs. SSP1-M 2050, SSP2-M 2050 & SSP3-H 2050)	Although the technological components required for MCS are relatively mature and the system could be deployed within a limited time span, various elements prevent this mCDR technology from large-scale implementation, e.g., legal barriers, high degrees of uncertainty regarding its environmental impacts, efficiency, and cost-effectiveness (NASEM, 2022). Nevertheless, given the projected CDR gap of 5.2 $GtCO_2yr^{-1}$ by 2050 (Lamb et al., 2026), it is plausible that MCS may become part of the broader portfolio of mCDR technologies in the coming decades. As mCDR technologies are intended for deployment within future low-carbon societies, the environmental performance of MCS will strongly depend on the socio-economic and technological context in which it is implemented. In particular, future developments in electricity generation, transportation, and industrial production systems could substantially influence the environmental impacts associated with the technology (Sacchi et al., 2022). Therefore, while the mature foreground processes are unlikely to differ substantially in future conditions, the background conditions under which MCS is implemented is likely to witness substantial change. Hence, incorporating prospective LCI background data enables the assessment of how sensitive the environmental performance of MCS is to future conditions.
LCIA method family (ReCiPe vs. IMPACT world+)	As argued by Delval et al. (2025), the choice of LCIA method family could influence the environmental outcomes of the LCA, as different models rely on varying assumptions, impact pathways, and characterisation factors, potentially affecting both the magnitude and relative importance of impact categories. Therefore, a sensitivity analysis with an alternative LCIA method family should be performed to evaluate the effect of this modelling choice (Delval et al., 2025).
Cultivation/sinking line material (flax vs. polyethylene, fleece)	Due to the design of the deposition concept adopted from Coleman et al. (2022), in which the macroalgae are sunk to the deep sea while still attached to the cultivation line, this specific component of the cultivation infrastructure has a large material footprint. Moreover, while Coleman et al. (2022) advocate the use of natural longline materials, contemporary macroalgae cultivation systems commonly rely on polyethylene longlines (van Oirschot et al., 2017; Koesling et al., 2021; Thomas et al., 2021). Consequently, both the substantial environmental contribution as highlighted in our results and uncertainty surrounding longline material usage warrant the assessment of the sensitivity of the product system to alternative longline materials.
Line seeding method (spray-seeding vs. submersion seeding)	To obtain a seeded line ready for deployment at sea, the two most successful methods employed at existing macroalgae cultivation facilities, and the ones for which reliable data could be acquired, are spray-seeding and submersion seeding. Both differ in terms of their operational inputs and associated energy requirements (Thomas et al., 2021). Slegers et al. (2021) argue that cultivation technologies and seedling breeding strategies could significantly influence the environmental performance of macroalgae systems. Moreover, while submersion seeding is traditionally applied, Boderskov et al. (2021) also highlight operational differences between both methods. Therefore, evaluating the sensitivity of the MCS system's performance to seeding technologies is considered worthwhile.
Parameters of interest (continuous) (50-150, with 25% increments)	
Carbon/nutrient leakage	Our contribution analysis revealed that leakage of sequestered carbon and nutrients before the end of the sequestration time horizon constitutes one the largest environmental hotspots within the MCS system. Moreover, although leakage estimates from Baker et al. (2022) were adopted in the present study, long-term sequestration pathways remain uncertain and geographically dependent (Siegel et al., 2021; Passarona et al., 2023; Bauer et al., 2026). Therefore, as argued by Delval et al. (2025), the sensitivity of mCDR systems to storage security and carbon leakage should be explicitly evaluated through sensitivity analysis, particularly for approaches where reversibility remains uncertain.

Biomass yield	In practice, macroalgae biomass yields can fluctuate considerably between cultivation cycles, for example reflecting differences in disease and storm exposure, or even slight variations in cultivation procedures (Thomas et al., 2021; Khan et al., 2024). This is reflected by Zhang et al. (2022), who investigated nine *S. latissima* cultivation sites and reported a yield difference of +140% and -85% compared to the average between all macroalgae farms. Additionally, factors such as harvesting depth and month could further influence biomass productivity, and future yields are expected to increase due to changes in areas such as seeding techniques and cultivation infrastructure (Koesling et al., 2021; Slegers et al., 2021). As biomass yield is directly linked to the amount of material and energy inputs required to achieve the FU, it may substantially influence the overall environmental performance of the MCS system and is therefore relevant to assess through sensitivity analysis.
Distance to sink-site	Our contribution analysis revealed that transportation of macroalgae biomass to the sink-site presents a significant environmental hotspot, which aligns with findings of Slegers et al. (2021) and Coleman et al. (2022), prompting the former to include transportation distance in their sensitivity analysis. At the same time, the distance to the nearest sink-site is highly geography dependent, which causes impacts to differ between cultivation sites. Hence, assessing the impact of variations in this parameter could provide valuable insights regarding where to implement MCS.

S.4 Adaptations to variables for sensitivity analysis

Table S4-1: Overview of the LCI flows modified for the sensitivity analysis of continuous parameters, including: (i) distance to sink site, (ii) biomass yield, (iii) carbon/nutrient leakage. The values are presented for the 50%, 75%, base-case, 125%, and 150% scenarios and show the adaptations applied to the LCA model to reflect the changing conditions across the three parameters of interest.

Parameter	Variable	Product system stage	50%	75%	Base-case	125%	150%
Distance to sink site	Market for transport, freight, inland waterways, barge, diesel (RER)	Offshore transportation and deep-sea deposition	3548.66 t*km	5322.99 t*km	7097.32 t*km	8871.65 t*km	10645.97 t*km
Biomass yield	Mature macroalgae	Cultivation at sea	500 kg	750 kg	1000 kg	1250 kg	1500 kg
	Carbon dioxide, fossil	Cultivation at sea	-72.60 kg	-108.89 kg	-145.19 kg	-181.49 kg	-217.79 kg
	Nitrogen	Cultivation at sea	-2.04 kg	-3.06 kg	-4.08 kg	-5.10 kg	-6.12 kg
	Phosphorus	Cultivation at sea	-0.18 kg	-0.27 kg	-0.36 kg	-0.45 kg	-0.54 kg
	Market for transport, freight, inland waterways, barge, diesel (RER)	Offshore transportation and deep-sea deposition	7150.15 t*km	7123.85 t*km	7097.55 t*km	7084.40 t*km	7071.25 t*km
Carbon/nutrient leakage	Harvested macroalgae	Offshore transportation and deep-sea deposition	8250 kg	9150 kg	10270 kg	11720 kg	13640 kg
	Carbon dioxide, fossil	Offshore transportation and deep-sea deposition	197.60 kg	328.90 kg	492.06 kg	702.12 kg	980.18 kg
	Nitrogen	Offshore transportation and deep-sea deposition	5.55 kg	9.24 kg	13.82 kg	19.72 kg	27.52 kg
	Phosphorus	Offshore transportation and deep-sea deposition	0.49 kg	0.82 kg	1.23 kg	1.75 kg	2.45 kg
	Waste concrete, not reinforced (Europe without Switserland)	Offshore transportation and deep-sea deposition	1466.89 kg	1627.72 kg	1826.42 kg	2084.86 kg	2425.46 kg
	Market for transport, freight, inland waterways, barge, diesel (RER)	Offshore transportation and deep-sea deposition	5710.11 t*km	6330.74 t*km	7097.56 t*km	8094.94 t*km	9409.34 t*km

Table S4-2: Overview of LCA model and calculation set-up modifications applied in the discrete parameter sensitivity analysis. The table presents the differences between the base-case configuration and the corresponding alternatives, i.e., (i) potential future scenarios (SSP1-M, SSP2-M, and SSP3-H; 2050), (ii) LCIA method family (IMPACT World+), and (iii) main cultivation line material.

Parameter	Variable	Product system stage	Base-case	Sensitivity analysis
Time	Background LCI database	Complete LCA model	Ecoinvent v3.12 - cutoff	Ecoinvent v3.12 – cutoff – IMAGE SSP1-M 2050 (adapted using *premise*)
				Ecoinvent v3.12 – cutoff – IMAGE SSP2-M 2050 (adapted using *premise*)
				Ecoinvent v3.12 – cutoff – IMAGE SSP3-H 2050 (adapted using *premise*)
LCIA method family	Impact categories	N/a (concerns LCIA)	ReCiPe 2016 v1.03, midpoint (H) – Climate change	IMPACT World+ v2.1 – Climate change
			ReCiPe 2016 v1.03, endpoint (H) – Ecosystem quality	IMPACT World+ v2.1 – Ecosystem quality
			ReCiPe 2016 v1.03, endpoint (H) – Human health	IMPACT World+ v2.1 – Human health
			ReCiPe 2016 v1.03, endpoint (H) – Energy resources: non-renewable	IMPACT World+ v2.1 – energy resources: non-renewable
Main cultivation line material	Market for fibre, flax (GLO)	Cultivation at sea	7.64kg	N/a
	Market for fleece, polyethylene (GLO)	Cultivation at sea	N/a	17.25kg

Table S4-3: Overview of the LCI of the line seeding stage, specifying the differences in input/output required to produce sufficient collectors to provide one tonne of S. latissima biomass between the two line seeding alternatives, i.e., submersion and spray seeding, based on Thomas et al. (2021) and Ayala et al. (2023).

Inventory inputs and unit processes	Input/output type	Amount		Unit	Providing process, ecoinvent v.3.12 – cutoff background process, or biosphere 3 flows
		Submersion seeding	Spray seeding		
Line seeding					
Inflows					
Concentrated solution of healthy spores	N/a	1.00E+00	1.00E+00	l	Spore preparation
Aeration and stirring system	Electricity, medium voltage	2.04E+00	1.24E-00	kWh	Market group for electricity, medium voltage (RER)
Aquaria	Polymethyl methacrylate	2.91E-01	2.91E-01	kg	Market for polymethyl methacrylate (RER)
Production of aquaria	Injection moulding	2.91E-01	2.91E-01	t*km	Market for injection moulding (GLO)
Bucket	Extrusion, plastic pipes	1.13E-02	1.13E-02	kg	Market for extrusion, plastic pipes (GLO); adjusted by replacing

					plastic inputs with “Polyethylene, high density, granulate”
Collectors	Extrusion, plastic pipes	2.75E-01	2.75E-01	kg	Market for extrusion, plastic pipes (GLO); adjusted by replacing plastic inputs with “polyvinylidenchloride, granulate”
Autoclave	Electricity, medium voltage	N/a	4.67E-02	kWh	Market group for electricity, medium voltage (RER)
Lighting system	Electricity, medium voltage	9.19E+00	5.78E-00	kWh	Market group for electricity, medium voltage (RER)
Seawater filter	Fleece, polyethylene	3.02E-02	3.02E-02	kg	Market for fleece, polypropylene (GLO)
Seawater filter	Steel, chromium steel 18/8	3.36E-03	3.36E-03	kg	Market for steel, chromium steel 18/8 (GLO)
Seawater source and filter system	Electricity, medium voltage	2.62E-02	1.51E-02	kWh	Market group for electricity, medium voltage (RER)
Seeding line	Nylon 6	1.58E-01	1.58E-01	kg	Market for Nylon 6 (Row)
Temperature control system	Electricity, medium voltage	7.08E+00	4.31E+00	kWh	Market group for electricity, medium voltage (RER)
Water heating system	Electricity, medium voltage	3.33E-01	3.33E-01	kWh	Market group for electricity, medium voltage (RER)
Nutrient mix (modified ES medium)	Sodium nitrate	9.74E-01	5.85E-01	g	Market for sodium nitrate (GLO)
	EDTA, ethylenediamine-tetaacetic acid	1.29E-02	7.75E-03	g	Market for EDTA, ethylene-diaminetetaacetic acid (GLO)
	Ammonium sulfate	1.77E-01	1.06E-01	g	Market for ammonium sulfate (RER)
	Boric acid, anhydrous, powder	1.13E-02	6.81E-03	g	Market for boric acid, anhydrous, powder (GLO)
	Manganese sulfate	1.21E-03	7.30E-04	g	Market for manganese sulfate (GLO)
	Zinc monosulfate	2.23E-04	1.34E-04	g	Market for zinc monosulfate (RER)
	Tap water	2.53E-01	1.52E-01	l	Market for tap water (Europe without Switzerland)
Outflows					
Collector (seeded line)	N/a	1.00E+00	1.00E+00	item	N/a
Solid waste	Municipal solid waste	6.11E-01	6.11E-01	kg	Market group for municipal solid waste (RER)
Wastewater	Market for wastewater, average	2.53E-04	1.52E-04	m^3	Market for wastewater, average (Europe without Switzerland)

S.5 Process contribution analysis climate change

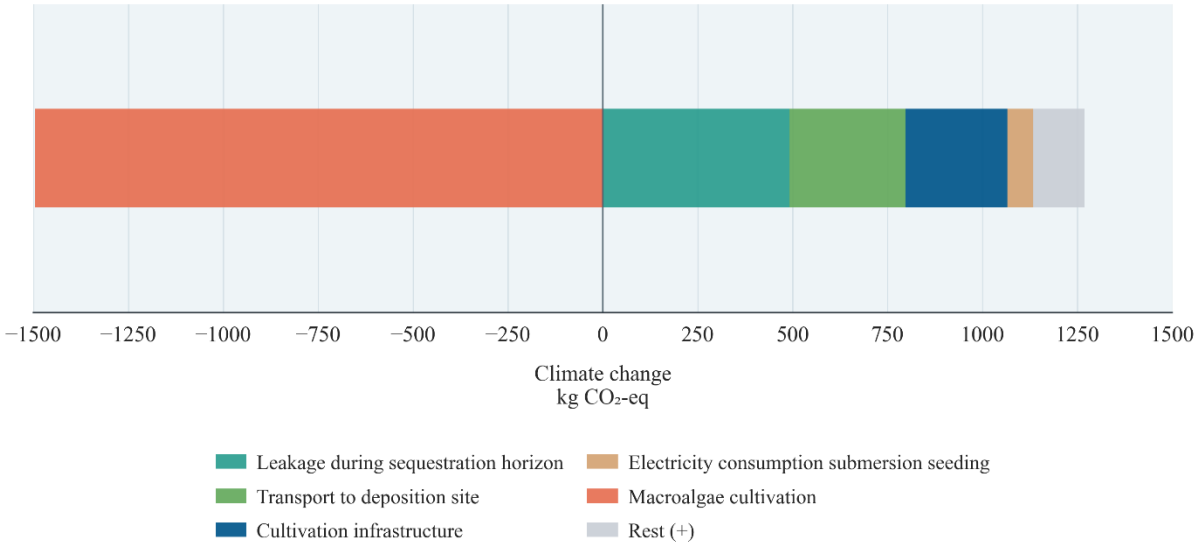


Figure S5: Absolute contributions of the main processes associated with the climate change impact of durably sequestering one tonne of CO_2 through MCS, assessed using the ReCiPe 2016 v1.03 midpoint (H).

S.6 Process contribution analysis MCS to midpoint and endpoint indicators

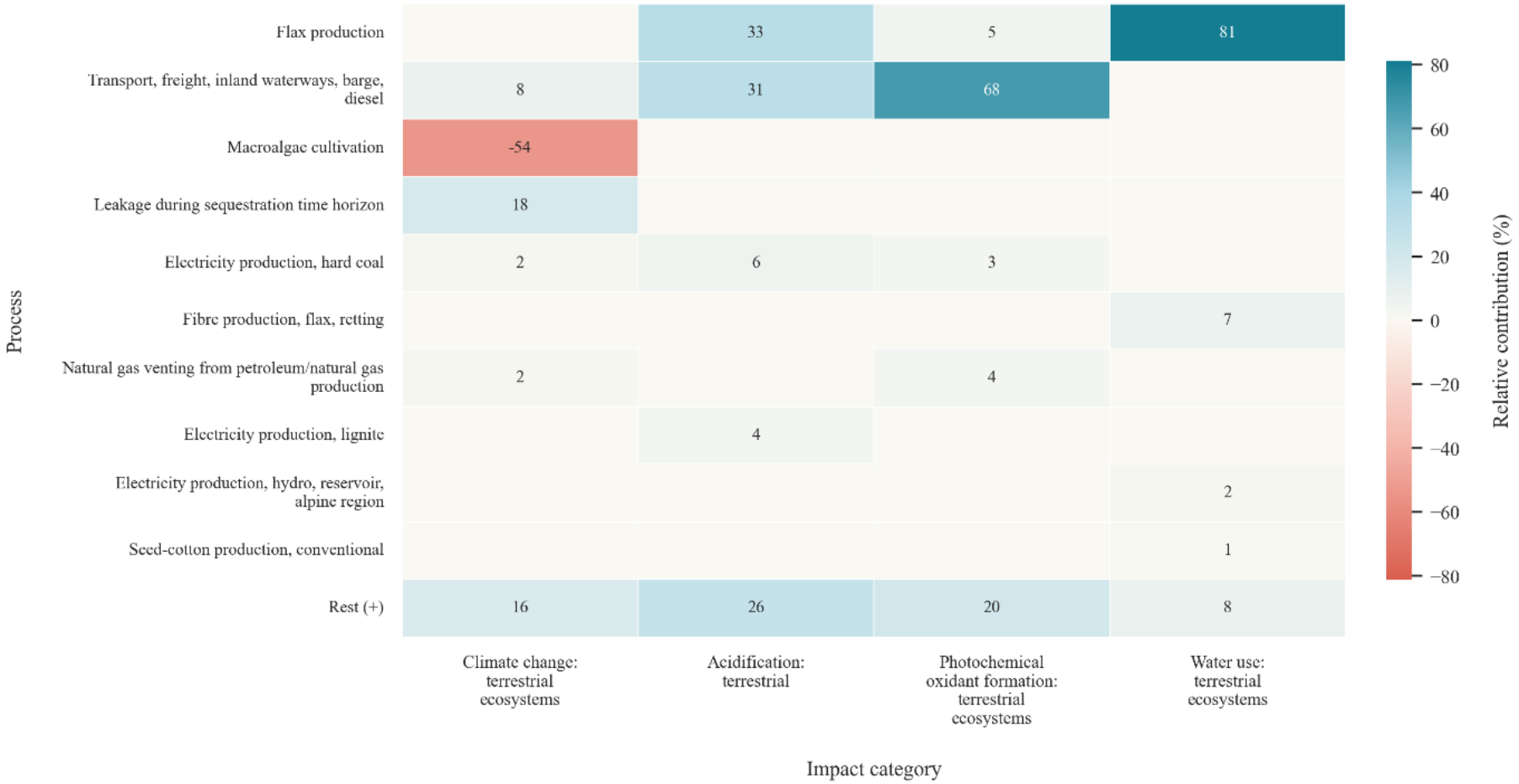


Figure S6-1: Relative contributions of dominant processes to the four largest contributing midpoint impact categories affecting ecosystem quality, i.e., (i) climate change: terrestrial ecosystems, (ii) acidification: terrestrial, (iii) photochemical oxidant formation: terrestrial ecosystems, and (iv) water use: terrestrial ecosystems. Results are expressed as relative contributions within each impact category (note: red indicates impact reductions, hence benefits, whereas blue indicates damages) and were assessed using ReCiPe 2016 v1.03 endpoint (H).



Figure S6-2: Relative contributions of dominant processes to the four largest contributing midpoint impact categories affecting human health, i.e., (i) climate change: human health, (ii) human toxicity: carcinogenic, (iii) human toxicity, non-carcinogenic, and (iv) particulate matter formation. Results are expressed as relative contributions within each impact category (note: red indicates impact reductions, hence benefits, whereas blue indicates damages) and were assessed using ReCiPe 2016 v1.03 endpoint (H).

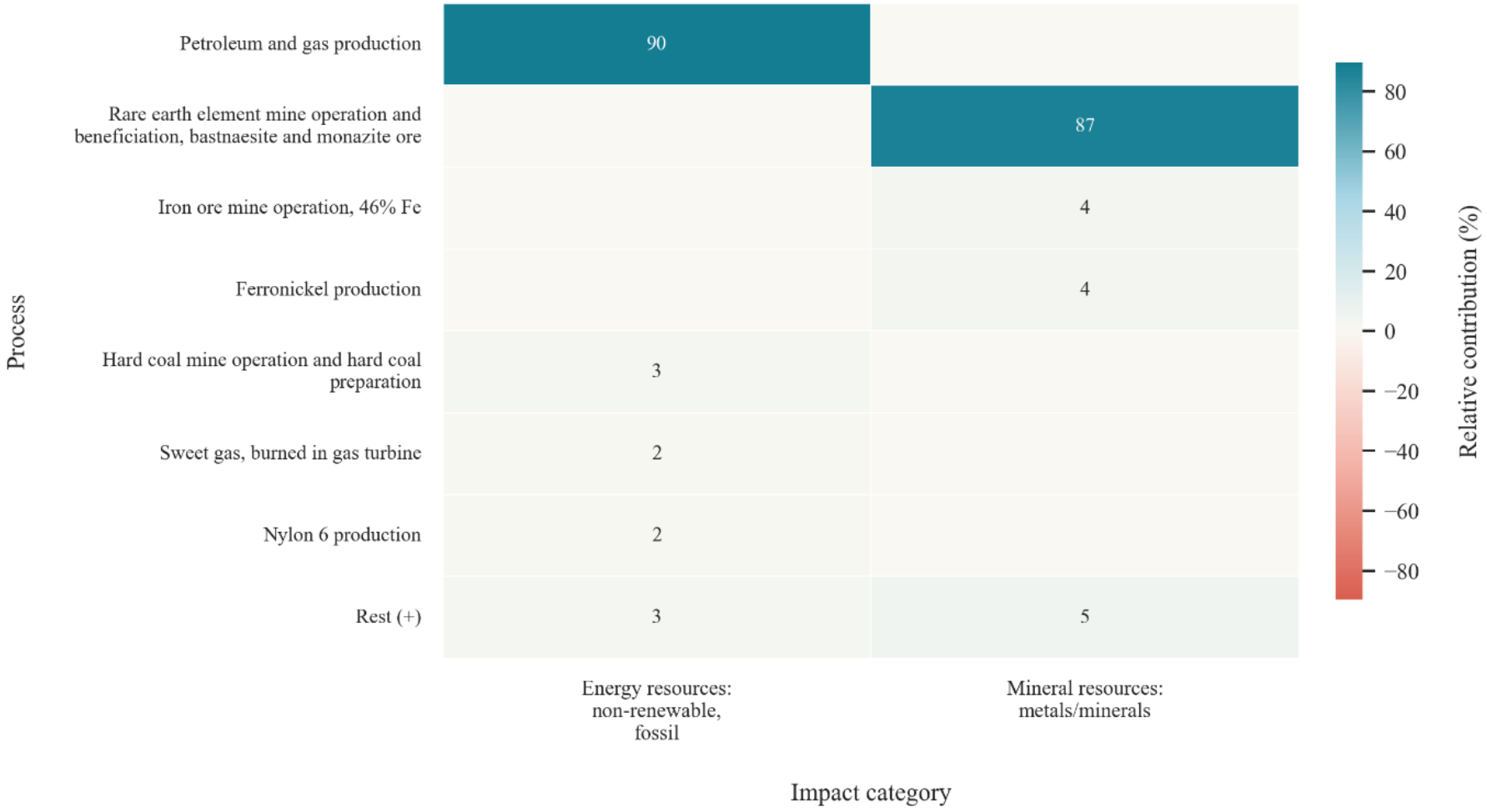


Figure S6-3: Relative contributions of dominant processes to both midpoint impact categories affecting total natural resource depletion, i.e., (i) energy resources: non-renewable, fossil, and (ii) mineral resources: metals/minerals. Results are expressed as relative contributions within each impact category and were assessed using the ReCiPe 2016 v1.03 endpoint (H).



Figure S6-4: Relative contributions of dominant processes to endpoint indicators, i.e., ecosystem quality, human health, and natural re source depletion (note: red indicates impact reductions, hence benefits, whereas blue indicates damages), assessed using ReCiPe 2016 v1.03 endpoint (H).

Figure S6-4 shows that for ecosystem quality, 29% of impacts can be traced back to biomass transport and C and nutrient leakage, supporting the pronounced impact of the offshore transportation and deposition stage. While cultivation has a net-mitigating effect, the contribution analysis also reveals that the cultivation infrastructure included in this stage constitutes 22% of the total ecosystem quality impacts, primarily through flax fibre production (15%). Similar trends are observed for human health, although the smaller net-mitigating effect of cultivation is explained by greater impacts from the infrastructure (25%) and municipal solid waste treatment (6%), largely offsetting the benefits of macroalgae growth. Additionally, the relatively large impacts from line seeding on human health can be traced back to electricity consumption at the nursery facility. In contrast, resource scarcity is driven by a markedly different set of processes. Neither macroalgae growth nor carbon and nutrient leakage contributes to this endpoint category, instead, 45% its impacts are caused by transportation to the deposition site, and 39% by the cultivation infrastructure (most of which due to the polyethylene lines, anchor buoys, and steel chackles, explaining the large contributions of cultivation and offshore transportation and deposition stages for resource depletion above.

S.7 Sensitivity analysis of different future background conditions

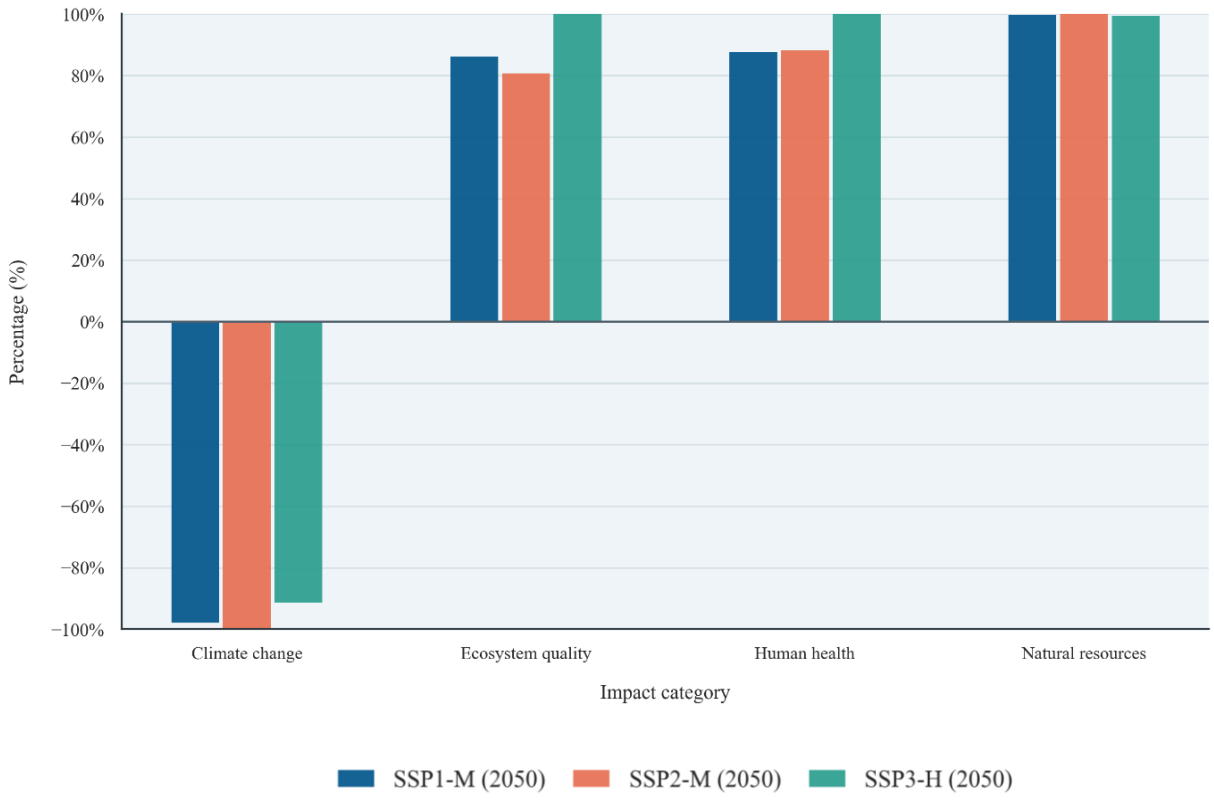


Figure S7: Relative performance of the MCS system under different future background conditions for the climate change and endpoint impact categories. Results are normalised to the largest impact within each impact category and assessed using ReCiPe v.1.03 (H).

Only minor differences can be observed between the environmental performance of MCS due to variations in socio-economic pathways by 2050. While the results for ecosystem quality and human health show a larger extent of sensitivity, the overall outcomes change by <20%. Notably, SSP2-M results in slightly favourable climate change impacts compared to SSP1-M. Further analysis revealed that this can be traced back a reduction of 72.0% in electricity consumption impact during the line seeding stage, one of the main contributors (Chapter 3.1), between the two pathways; showing that the energy mix used in SSP2-M performs favourably compared to the one in SSP1-M by 2050.

References

Ayala, M., Thomsen, M., & Pizzol, M. (2023). Life Cycle Assessment of pilot scale production of seaweed-based bioplastic. Algal Research, 71, 103036. https://doi.org/10.1016/j.algal.2023.103036

Baker, C. A., Martin, A. P., Yool, A., & Popova, E. (2022). Biological Carbon Pump Sequestration Efficiency in the North Atlantic: A Leaky or a Long-Term Sink? Global Biogeochemical Cycles, 36(6), e2021GB007286. https://doi.org/10.1029/2021GB007286

Bauer, K.W., Correa, P.V.F., Lupin, A. et al. In-situ deep ocean monitoring reveals rapid kelp degradation limits marine biomass-based carbon sequestration potential and alters benthic ecosystems. Commun Earth Environ (2026). https://doi.org/10.1038/s43247-026-03342-0

Boderskov, T., Nielsen, M., Rasmussen, M., Johannes, T., Balsby, S., MacLeod, A., Holdt, S., Sloth, J., & Bruhn, A. (2021). Effects of seeding method, timing and site selection on the production and quality of sugar kelp, Saccharina latissima: A Danish case study. Algal Research, 1, 102160. https://doi.org/10.1016/j.algal.2020.102160

Coleman, S., Dewhurst, T., Fredriksson, D. W., St. Gelais, A. T., Cole, K. L., MacNicoll, M., Laufer, E., & Brady, D. C. (2022). Quantifying baseline costs and cataloging potential optimization strategies for kelp aquaculture carbon dioxide removal. Frontiers in Marine Science, 9. https://doi.org/10.3389/fmars.2022.966304

Delval, M. H., Thonemann, N., Henriksson, P. J. G., Tanzer, S. E., & Behrens, P. (2025). Life cycle assessment of ocean-based carbon dioxide removal approaches: A systematic literature review. Renewable and Sustainable Energy Reviews, 224, 116091. https://doi.org/10.1016/j.rser.2025.116091

European Marine and Data Network. (n.d.). EMODnet Map Viewer. Retrieved 8 May 2026, from https://emodnet.ec.europa.eu/geoviewer/

Khan, N., Sudhakar, K., & Mamat, R. (2024). Macroalgae farming for sustainable future: Navigating opportunities and driving innovation. Heliyon, 10(7), e28208. https://doi.org/10.1016/j.heliyon.2024.e28208

Koesling, M., Kvadsheim, N. P., Halfdanarson, J., Emblemsvåg, J., & Rebours, C. (2021). Environmental impacts of protein-production from farmed seaweed: Comparison of possible scenarios in Norway. Journal of Cleaner Production, 307, 127301. https://doi.org/10.1016/j.jclepro.2021.127301

Lamb, W. F., Vaughan, N. E., Reynolds, C., Fyson, C., Roman-Cuesta, R. M., Bergero, C. (2026). Chapter 9: The CDR gap, in The State of Carbon Dioxide Removal 3rd Edition 2026 (eds. Edwards, M. R. et al.). DOI: https://doi.org/10.17605/OSF.IO/FNQRM (2026)

National Academies of Sciences, Engineering, and Medicine. (2022). A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration. Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

National Oceanic and Atmospheric Administration (n.d.). Latitude/Longitude Distance Calculator. Retrieved 8 May 2026, from https://www.nhc.noaa.gov/gccalc.shtml

Oirschot, R. van, Thomas, J. B. E., Gröndahl, F., Fortuin, K. P. J., Brandenburg, W., & Potting, J. (2017). Explorative environmental life cycle assessment for system design of seaweed cultivation and drying. Algal Research, 27, 43–54. https://doi.org/10.1016/j.algal.2017.07.025

Pessarrodona, A., Franco-Santos, R. M., Wright, L. S., Vanderklift, M. A., Howard, J., Pidgeon, E., Wernberg, T., & Filbee-Dexter, K. (2023). Carbon sequestration and climate change mitigation using macroalgae: A state of knowledge review. Biological Reviews, 98(6), 1945–1971. https://doi.org/10.1111/brv.12990

Philis, G., Gracey, E. O., Gansel, L. C., Fet, A. M., & Rebours, C. (2018). Comparing the primary energy and phosphorus consumption of soybean and seaweed-based aquafeed proteins – A material and substance flow analysis. Journal of Cleaner Production, 200, 1142–1153. https://doi.org/10.1016/j.jclepro.2018.07.247

Sacchi, R., Terlouw, T., Siala, K., Dirnaichner, A., Bauer, C., Cox, B., Mutel, C., Daioglou, V., & Luderer, G. (2022). PRospective EnvironMental Impact asSEment (premise): A streamlined approach to producing databases for prospective life cycle assessment using integrated assessment models. Renewable and Sustainable Energy Reviews, 160, 112311. https://doi.org/10.1016/j.rser.2022.112311

Siegel, D. A., DeVries, T., Doney, S. C., & Bell, T. (2021). Assessing the sequestration time scales of some ocean-based carbon dioxide reduction strategies. Environmental Research Letters, 16(10), 104003. https://doi.org/10.1088/1748-9326/ac0be0

Slegers, P. M., Helmes, R. J. K., Draisma, M., Broekema, R., Vlottes, M., & van den Burg, S. W. K. (2021). Environmental impact and nutritional value of food products using the seaweed Saccharina latissima. Journal of Cleaner Production, 319, 128689. https://doi.org/10.1016/j.jclepro.2021.128689

Thomas, J.-B. E., Sodré Ribeiro, M., Potting, J., Cervin, G., Nylund, G. M., Olsson, J., Albers, E., Undeland, I., Pavia, H., & Gröndahl, F. (2021). A comparative environmental life cycle assessment of hatchery, cultivation, and preservation of the kelp Saccharina latissima. ICES Journal of Marine Science, 78(1), 451–467. https://doi.org/10.1093/icesjms/fsaa112

Zhang, X., Boderskov, T., Bruhn, A., & Thomsen, M. (2022). Blue growth and bioextraction potentials of Danish Saccharina latissima aquaculture—A model of eco-industrial production systems mitigating marine eutrophication and climate change. Algal Research, 64, 102686. https://doi.org/10.1016/j.algal.2022.102686