Technical guidelines for the implementation of living barriers technology and their commercialization

This report is prepared within the implementation of project LiveLagoons „The use of active barriers for the nutrient removal and local water quality improvement in Baltic lagoons", No. STHB.02.02.00-LT-0089/16, a cross-border coopeeration project of the Interreg South Baltic Cross-border Cooperation Programme 2014-2020

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Executive Summary

This guideline is a compilation of project experimental work conducted during the period 2017-2021 describing the process, and results of technical and scientific research on constructed floating islands in the coastal waters of the SE Baltic Sea (Curonian Lagoon, Lithuania; Szczecin Lagoon, Poland; Darss-Zingst Bodden Chain, Germany).

Key initiatives performed by the project partners included: testing of different floating wetland technologies in different environmental conditions (coastal embayment, coastal erosion section, bathing area, marina, aquaculture discharge canal, city center) and estimation of installation impacts (growth and accumulation of nutrients in the plant biomass, effects on water quality and biodiversity, coastal protection).

Location can have key importance for a long-term success of the installation. Things to consider while selecting the site are provided in summary in this guideline.

LiveLagoons project was also aimed to demonstrate the ways in which innovation is contributing to a coastal society by performing dissemination workshops, public days, lectures and meetings with stakeholders as well as companies. The crowdfunding campaign on floating island installation in Klaipeda City center was launched to demonstrate that installation of the floating island is rising awareness on the coastal environment: eutrophication, climate change, coastal protection, and biodiversity. The willingness of local society to contribute to such initiative via financial support was limited, instead of few specific segments such as coastal municipalities, charity funds, restaurant owners showed an interest in investments into further development of the technology. There is potential (governmental and private) for further growth of green infrastructure development and floating wetland market in the SB region.

It could be offered for customers as an element of green infrastructure to enhance local natural capital and general environmental improvement. The challenge of local manufacturers and developers is to make it environmentally friendly (using non-hazardous, plastic-free materials) sustainable construction at low production costs. Low maintenance costs and skills, as well as a variety of possible applications, will certainly rise a demand of the product in the future.

In this guideline, we describe the specific practical aspects of installation and maintenance of floating islands, assessment on overall applicability of living barriers as well as provide guidance on commercialization and marketing for the potential developers of this technology.

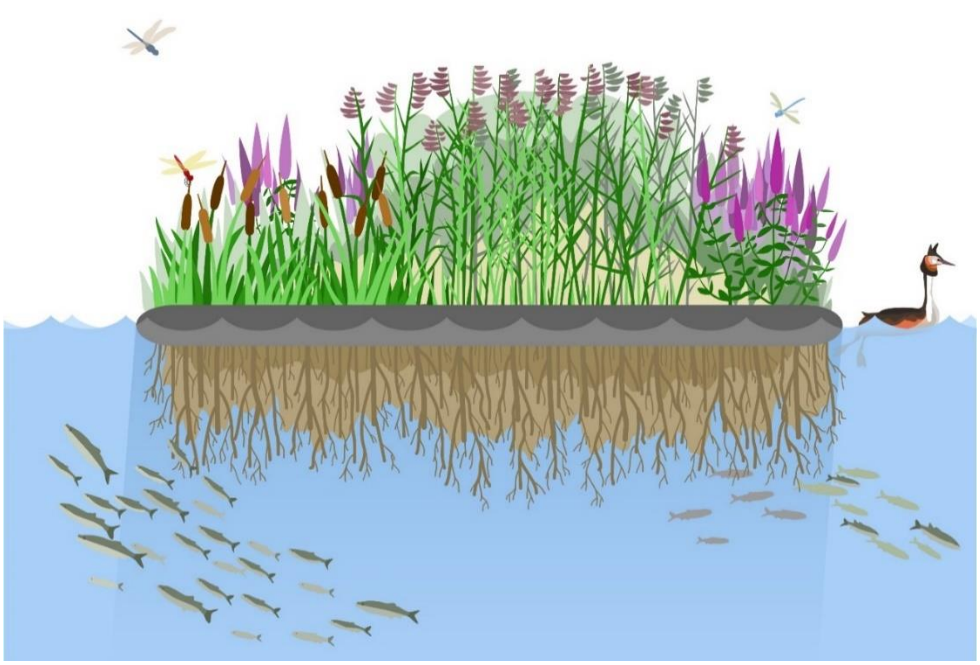
I. Introduction to Floating Islands

Eutrophication is a major environmental issue in the coastal waters significantly contributing to natural habitat and recreational water quality loss. River basin nutrient management confronts severe limitations in land use and agricultural practices, therefore internal nutrient removal measures are implemented to protect coastal waters from the further increase of eutrophication and habitat restoration.

Constructed floating wetland (CFW) or artificial floating wetlands (AFW) is an eco-engineering solution increasingly applied for water restoration and creation of natural floating riverbanks in the cities with other multiple benefits for the society. Wetland plants are supported by artificial buoyant mats. Therefore, AFWs are an innovative variant of a constructed treatment wetland that allows non-land-based water treatment in water bodies that are too deep for plants to grow and under fluctuating water levels (Grosshans et al., 2019).

Nutrient-rich water is treated by bacteria attached to the plant roots performing nitrification/denitrification (release of N_2 gas), biological breakdown, and detoxification. Roots and installation themselves enhance particle retention. As a result, increased water clarity, reduced algae, and cyanobacteria growth, as well as reduced nutrient levels, could be achieved. The increased habitat and food availability further enhance the aquatic food chain and partly restore deteriorated biodiversity in turbid waters. In addition, floating wetlands provide habitats for aquatic and terrestrial fauna (insects, birds) as well as a number of cultural services.

The application of floating wetlands as a tool for enhanced stormwater treatment has been tested worldwide. During recent decades the commercially available floating matts (e.g. BioHaven®, Biomatrix®, AquaGreen® or Beemats®) are increasingly applied as the



technique to create artificial wetland for diffuse pollution treatment, water quality improvement, and biodiversity habitat creation. This guideline contains factsheets on testing of the technology in the South Baltic Region with a special focus on local natural conditions and specifics of Nordic climate conditions at a variety of sites for further development of the market for this green infrastructure.

History and origin

The artificial gardens have been utilized for the cultivation of crops and vegetables from the historical times. Artificial islands have been invented by Aztec civilization. These land strips surrounded by the canals have been built using wood sticks, plant material and mud which was excavated from the bottom of the canal and placed on the top of the bed. Although called 'floating islands' these agricultural constructions were not floating but rather stable. Nowadays, floating platforms, a method of hydroponics, called *baira* are still widely used in India, Myanmar, and Bangladesh during the monsoon rain flooding periods which hamper traditional land-based agriculture in large areas commonly known as "Vasoman Chash" (IUCN Bangladesh, 2005; Moniruzzaman et al., 2020). Local organic materials from plant biomass (such as water hyacinths, straw, willows, coconut fibers), are used to build and fasten the platforms (Chowdhury, Moore, 2017).

Artificial Floating Wetlands (AFW) have been considered as a measure in the wastewater treatment process relatively restricted to the use in domestic wastewater treatment or stormwater ponds (Jason et al. 2019, Borne 2014, Barco and Borin 2020, Maxwell et al. 2020). Nowadays, it is considered a nature-based solution (NbS) serving multiple purposes from nutrient and persistent pollutant removal to coastal protection as well as habitat and biodiversity restoration (Pavlineri et al. 2017). They became a popular choice, especially in degraded or heavily modified environments, providing or restoring several ecosystem services.

Benefit for Society and Ecosystem services

Floating wetlands offer a bundle of regulating and cultural ecosystem services: habitat provision, nutrient removal, wave attenuation, tourist attraction, and nature education. The total economic value of ecosystem service provision per area is still under investigation. Preliminary it could be estimated that AFW nutrient removal and carbon sequestration potential is low because of the small area, however, the biodiversity, aesthetic, and education opportunity value is high. Moreover, choosing the right location, layout, and collection of plants could make an added value to this semi-natural landscape element.

In the Livelagoons project, the value of cultural ecosystem services becomes apparent via the number of media inquiries, interviews, TV episodes, and articles showing great public interest and raising awareness about environmental issues. For example, watch interwiev on EuroNews program SMART Regions https://www.euronews.com/embed/1757326.

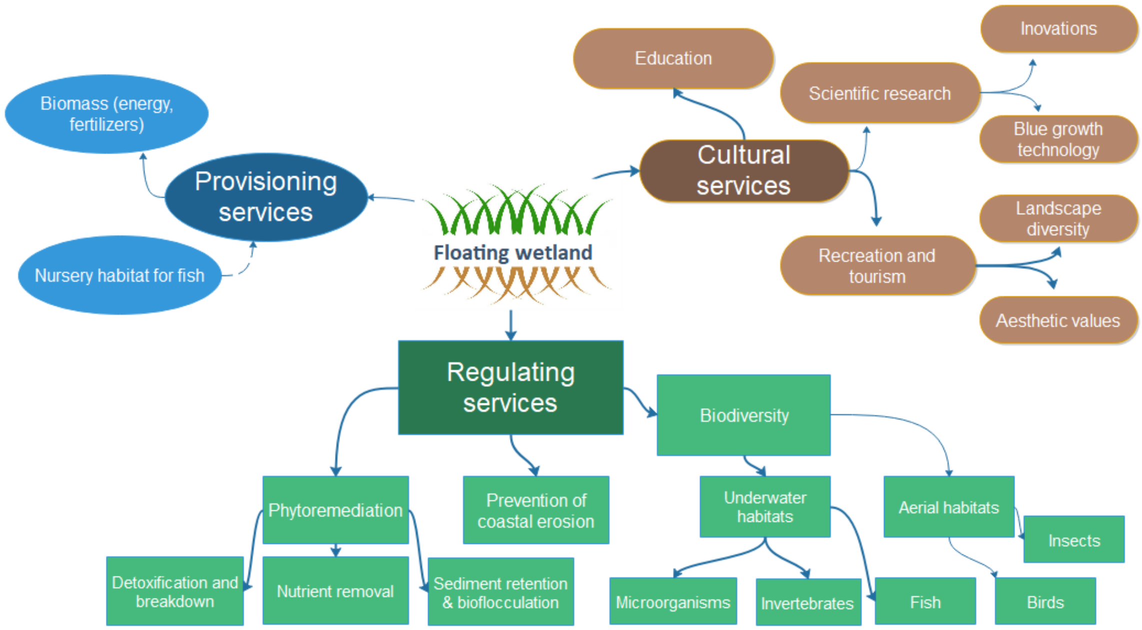


Fig. 1. Scheme showing the AFW linkage to Biodiversity and Ecosystem Services.

Nutrient removal capacity

The nutrient removal capacity of the island is the sum of nutrients accumulated in the aerial biomass (stems and leaves) and underwater biomass (roots), nitrogen loss by microbial activity, phosphorus uptake by microorganisms and sedimentation. Our estimates of plant biomass (Mix of *Carex acutiformes*, *Scirpus silvaticus* and *Typha*) and nutrient content in the harvest from the island (Biomatrix Water construction) installed in the Curonian Lagoon equal to 2.3kg/m^2 of total fresh weight, 10.3g/m^2 of N and 0.5g/m^2 of P. Some investigations report, that the aerial biomass could contribute only ~10% of nutrient removal while the rest is accounted for the root-associated microbial community. Therefore, we could assume that the total annual removal of 100 m^2 could be ~10x higher ~1000g of N and ~50g of P. In the long term the six years' cumulative removal could be 6kg N and 0.3kg P.

Table 1. AFW short-term impact by area. Numbers are given for the harvest removed from the AFW. The total impact for N and P removal could be ~10x higher.

Area, m2	Biomass, fresh weight kg			Nitrogen, gN			Phosphorus, gP		
	1yr	3ys	6ys	1yr	3ys	6ys	1yr	3ys	6ys
1	**2.3**	6.9	13.8	**10.3**	30.9	61.8	**0.5**	1.5	3
10	23	69	138	103	309	618	5	15	30
100	230	690	1380	1030	3090	6180	50	150	300

Biodiversity

AFW are well adopted as habitats by birds, fish, amphibians, crustaceans, mollusks and insects. The large and diverse root network benefits not only nutrient removal capacity but serves also as a shelter for endangered species. In the brackish Darss-Zingst-Bodden-Chain show the European eel (*Anguilla anguilla*) and shrimps (*Palaemon elegans*) discovered underneath the island. Mallard (*Anas platyrhynchos*) built a nest every year on one of the constructed island in Juodkrante (Curonian National Park, Lithuania). In the urban areas, where bird habitat is particularly restricted the AFW could become a place of schooling birds.

At high numbers, birds become a nuisance while grazing pressure can deteriorate plant condition significantly, especially at the early plant establishment stage. Bird protecting fens could be used or plant species resistant to bird grazing (*Sagittaria, Iris, Carex*). The public interest and enjoyment of birds are very high, so the fence could be removed at later island development stage to let birds enter the island.

Aesthetic value

Aesthetic value is the imminent added value of the AFW. In the boreal climate condition, the seasonality of the island view is an important factor creating interesting observation opportunities for visitors. The peak aesthetic view of the island is in late spring and summer when different plant species are in bloom. Some ornamental species such as e.g. Carex create colorful fall views and contrast the withering vegetation and naked trees in November. The aesthetic aspect is important in defining the value proposition for the customers and is most important in the visual advertisement.

Pictures Figs. 2-3 show seasonal change of the island of Jonas hill in Klaipeda, Lithuania.

Fig. 2 AFW in Klaipeda, Lithuania June 23 and July 16, 2021

Fig. 3. AFW in Klaipeda, Lithuania November 23 and December 8, 2021.

AFW as Green Infrastructure

The maintenance and enhancement of ecosystem services are also seen as a fundamental part of any strategy for dealing with future environmental change (Potschin and Haines-Young, 2011). ‘Green infrastructure is a successfully tested tool for providing ecological, economic, and social benefits through natural solutions. It helps us to understand the value of the benefits that nature provides to human society and mobilize investments to sustain and enhance them. It also helps avoid relying on infrastructure that is expensive to build when nature can often provide cheaper, more durable solutions. Many of these create local job opportunities. Green Infrastructure is based on the principle that protecting and enhancing nature and natural processes, and the many benefits human society gets from nature, are consciously integrated into spatial planning and territorial development. Compared to single-purpose, grey infrastructure, GI has many benefits. It is not a constraint on territorial development […].’ COM/2013/0249

The European Commission sees an overall high return of investments into green infrastructure with a cost-benefit ratio ranging from 3 to 75 COM/2013/0249. Tourism and export based on a 'clean & green' image of the area provide additional benefits to the local and regional economy, by attracting inward investment and enhancing local image and quality of life.

AFW as Compensatory measure

The human footprint of built areas is giant. The total production of concrete, metal, plastic, bricks and asphalt is greater than mass of living matter on our planet. The anthropogenic mass surpassed global living biomass in 2020 (±6 ys), the *Nature* paper says (Elhacham et al., 2020). Environmental compensation should partly neutralize negative impacts from human activities on nature, including loss of biodiversity and ecosystem services (Cole et al., 2021). Payment for Ecosystem Services schemes are still under development such as biodiversity offsetting. It is an approach which enables land or wild biodiversity site owners to register their areas to provide offset ‘credits’ which than can be purchased by project developers to compensate for habitat loss elsewhere (Smith et al., 2013). Still the PES mostly is based on *in-kind* compensations, however, in the next decades, the market-based mechanism will be developed. Creation of AFW would be an option to compensate for habitat loss when building concrete embankments in the city rivers and canals as well as lagoon and sea embayments and fjords.

The crowdfunding campaign on floating island installation in Klaipeda City center was launched on Nutribute - Crowdfunding platform for the Baltic Sea (John Nurminen Foundation initiative, Finland). Unfortunately, at the same time social networking channels have been filled in with COVID-19 charity initiatives for hospitals and medical care, which in fact demonstrate that environmental issues will never be the top priority for the society. However finally it will have an increasing effect on life quality.

II. Installation Technicalities and Practicalities

Site search and legal requirements

The decision-making process to install the AFW starts with appropriate site selection taking into account hydrodynamics, access view and layout, and investigation of legal requirements at the selected site.

As is shown by Karstens et al. (2018), the legal framework and permit procedure for installations differ in SBR countries (Table 2). Maritime offices limit the site options for floating wetland installations the most. It is recommended, therefore:

- to approach stakeholders of the potential location
- take into account fisheries, tourism, maritime traffic, and nature protection areas in order to prevent spatial conflicts of use.

Table 2. showing examples of the permits required at demonstration sites.

Case study	Permits required (national language):	Permits required (English):	Relevant laws:	State authority (national language):	State authority (English):
Szczecin Lagoon, Mecklenburg-Vorpommern, Germany	Naturschutzrechtliche Genehmigung	Permission issued under environmental law	§13-18 BNatSchG, §40 NatSchAG M-V	Untere Naturschutzbehörde LK Greifswald-Vorpommern	Nature conservation authority of the district
	Wasserrechtliche Erlaubnis	Permission issued under water law	§8/9/43 WHG + §23/89 LWaG	Untere Wasserbehörde StALU Vopommern	Lower level water authorities
	Strom-und schifffahrtspolizeiliche Genehmigung	License of the river and shipping police	§31 WaStrG	Wasserstraßen-und Schifffahrtsamt WSA Stralsund	Waterways and Shipways Office
Puck Bay Pomorskie, Poland	Pozwolenie na wznoszenie i wykorzystywanie sztucznych wysp, konstrukcji i urządzeń	Permit for construction and usage of artificial islands, constructions and devices	Ustawa z dnia 21 marca 1991 r. o obszarach morskich i administracji morskiej - Art. 23	Urząd Morski w Gdyni	Maritime Office Gdynia
	Zgoda na zajęcie obszaru morskich wód wewnętrzynych	Permit for use of internal marine waters area	Prawo Wodne, art. 20 ust. 1, pkt. 4	Urząd Morski w Gdyni	Maritime Office Gdynia
	Uzgodnienie sposobu oznakowania wyspy	Agreement on a way (method) of marking the island	Rozporządzenie Ministra Transportu, Budownictwa I Gospodarki Morskiej z dnia 4 grudnia 2012 r. w sprawie oznakowania nawigacyjnego polskich obszarów morskich	Kapitanat portu we Władysławowie	Władysławowo harbour authority
Curonian Lagoon Neringa, Lithuania	Leidimas	Permit for the construction in the coastal zone	LR vidaus vandenų transporto kodeksas	Vidaus vandenų kelių valdytojais (Neringos savivaldybė)	Neringa municipality
	Leidimas	Permit for the construction in the waterways and port areas	LR vidaus vandenų transporto kodeksas	Aplinkos Apsaugos Agentūra	Environmental Protection Agency

Hydrodynamics

If the planned floating wetland installation site is a pond or enclosed embayment, waiving and water flow damage risk for the construction is low. If it is an open coastline or flooded area it could be important to consider risks of damage and additional measures for fastening and touch the anchor device. Therefore, it is important to collect some data at the location:

- Depth at the installation site
- Fluctuation of the water level
- Maximal wave height
- Maximal wind speed (max record during 50 ys period if available)
- Max current horizontal velocity
- Risks of ice damage or flood

Important is to foresee the possible island effect on local water movement and sediment accumulation condition. It could contribute to wave energy attenuation and reduction of coast erosion.

Access

The access of the location is important because of two aspects: i) for the convenience of the installation and maintenance of the construction; ii) for the visibility of visitors. The floating wetland is produced and built in sections. The size and configuration of the island might be important to consider for transportation, removal to shelter during the ice period, and gardening harvesting practice. Visibility of installations and proximity to the coast are important decision factors for stakeholders (Karstens et al. (2018). Aesthetic enjoyment could be higher while having access for closer observation of the AFW from riverside walk, bridge, and pantone.

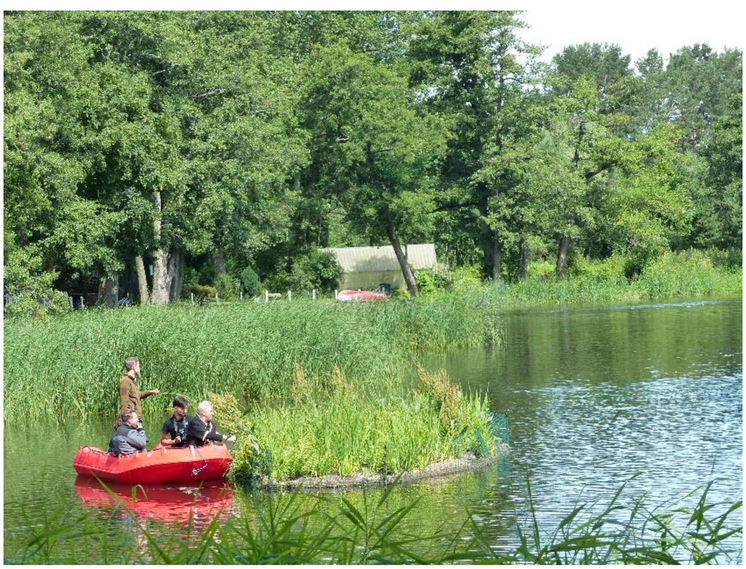


Fig. 4. Gintaro Bay island Curonian Spit NP.

View and layout

Here we provide an example of Photoshop simulation of an installation to have an idea of how it fits in the planned location, for example, marina, what size and form is optimal at the site, and the resulting view of the installed AFW. More advanced urban planning and landscaping software could be used to develop precise large-scale designs for the development projects.

Fig. 5. Island in Wolin NP Poland.

Maintenance all year round

Plants

The choice of the right macrophyte species depends on the purpose of AFW. Plants are purchased from the suppliers.

In natural protected areas only, native plants could be selected:

- Perennial plants (the annual plants will grow spontaneously);
- Species resistant to local environmental conditions, e.g. salinity and climate.
- For nutrient removal choose *Carex acutiformis, Typha*, *Iris*, *Juncus, Sagittaria*, *Phragmites*.
- For biodiversity integration of endangered species (e.g. *Iris pseudacorus,* halophytes *Aster tripolium, Triglocin maritimum*);
- For aesthetic enjoyment integration of flowering plants such as *Lythrum salicaria*;
- Herbal collections (e.g. *Acorus calamus, Petasitis hybridus, P. spurius, Valeriana*);
- Invasive emergent macrophytes (e.g. *Spartina anglica*) can not be planted.

In the urban green areas exotic ornamental plants could be selected:

- Exotic flowering species (e.g. *Iris, Ligularia dentata*);
- Varieties forming structure and color;
- Some flowering species that need to be removed for the winter period in the cold climate (*Canna, Colocasia*);

- Trees and ornamental bushes (e.g. swamp cypress *Taxodium distichum*, *Viburnum*, *Hibiskus mosquetos*);
- Greens and vegetables for horticulture (salad, cucumber, basilica, mint)

Harvesting and ice period

Harvesting is optional in case the value proposition is based on the aesthetic function of AFW. However, if the nutrient removal function is in focus, timely harvesting of above-ground tissues in September needs to be ensured before the start of vegetation decay. The biomass is cut and removed from the AFW manually. The floating construction of 24m^2 can hold 1-3 adult persons' weight. It is recommended to think about biomass transportation and utilization (e.g. compost) before harvest, or even prior to the setting of planted species assemblage. Volunteers, local communities, and students could be involved in this activity.

Experience from the Wolin NP (Poland) AFW Installation in a small marina suggests that late harvesting right after the end of sailing and tourism season is an option to avoid loss of aesthetic value while still being able to remove harvest.

The construction could be kept in the water year-round, as freezing and thawing cycles do not seem to harm the islands. The floating wetland could be moved to a sheltered area before the water body is covered by ice. For annual plants especially ornamental species, the replanting costs are considered and this will need some labor work.

III. Market and Commercialization potential

Business/Product or Service description

The AFW Company would make floating construction and provide installation and maintenance services:

- AFW installation and mooring;
- Plant collection design and planting;
- Maintenance service (fencing, re-planting, harvesting, mechanical inspection);
- Custom design and application consultancy.

The full-service offering as well as Do-It-Yourself and self-service provision help customers to create islands themselves.

Value proposition

- Their efficiency, ease of installation and maintenance makes AFW an outstanding technology to improve water quality, reduce the habitat loss effect and get life and biodiversity back on the restored site.
- It provides a landscape aesthetic and the opportunity to observe nature from a close perspective right in the city.
- It educates people and provides opportunities for donation and *in-kind* compensation for destroyed nature.
- It improves the well-being of coastal city communities and helps to stay optimistic about the future.

Existing Market

The AFW market is defined as a small green infrastructure development sector. The total market size in the SBR is unknown but is expected to grow in the near future. The main environmental issue is the eutrophication and pollution, through hazardous substances, of the Baltic Sea creates substantial commercial opportunities around “blue” and “green” business models in response to the necessary environmental challenges faced by the region (Laschewski et al., 2014). Any startup producer would capture nearly 100% of this market, as based on our knowledge all currently available companies with similar service profiles (Table 3) are outside SBR.

The most notable stakeholders who accepted the first AFW installations in Lithuania is Neringa Municipality and Curonian Spit National park and Klaipeda city Municipality, in Poland it is Wolin National Park and Rostock IGA Park in Germany. We count at least 18 large administrative units along the coastline of the SBR, who might have an interest in purchasing the AFW.

Table 3. Examples of EU companies, small and medium enterprises applying AFW as nature based solution to enhance green infrastructure or implement mitigation measures against environmental degradation.

Name	SBR/Outside	Country	FW Applications
Ecolink	Outside	Portugal	Floating wetlands, ecotechnologies, water treatment, plants: http://www.ecolink.pt/
Engenho e Rio, Unipessoal Lda	Outside	Portugal	River ecosystem rehabilitation, ecological engineering technologies development: https://www.linkedin.com/company/engenhoerio/
EcoWyspa	Outside	Poland	Water quality improvement, biodiversity and bird habitat restoration
Biomatrix Water	Outside	UK	Water restoration, habitat creation, wastewater treatment, floating river walks & parks, living marinas, floating farms, flood protection.
SALIX	Outside	UK	https://www.salixrw.com/; nature-based engineering company in fresh, estuarine and marine environments
Frog Environmental	Outside	UK	Water quality improvement, wastewater treatment, coastal & inland erosion control, habitat restoration & biodiversity offsetting, aquaculture & horticulture, integrated landscape solutions
Ökon Vegetationstechnik	Outside	DE	Water quality improvement, erosion control, habitat restoration

Available technology

- AFW modular design built using local materials such as reed filling (tested);
- AFW floating construction built using 100% plastic-free i.e. termowood, foam glass gravel (introductory stage);
- AFW systems integrated with other technologies to improve the efficiency of water cleaning e.g. aeration supply (not-tested).
- Co-design solutions through experimental, i.e., custom-made processes.

Fig. 6. AFW segment manufactured by Klaipeda University by Mechanical and Marine Engineering Laboratory staff.

Market segments

- **AFW for Nature**. Restoration is the main AFW market segment with a primary focus on water quality and biodiversity restoration. The habitat creation for endangered species would be the highest added value of AFW installation. It requires basic set-up with local plant assemblage.

- **AFW for Image**. Landscaping and aesthetics is a commercial segment with high potential in the cities, new buildup areas or reconstructed grey areas into green areas. The application of AFW as an element of green infrastructure would require some more effort for plant selection, design and maintenance to keep it attractive.
- **AFW for clean Water**. Stormwater management is another potential sub-segment of AFW commercialization. The urban runoff is still lacking of adequate management and is potential source of pollution in to coastal waters of the SBR. Stormwater runs off of impervious surfaces such as parking lots, roof tops, and roadways. Research is needed to estimate the spatial feasibility of AFW installations at the stormwater discharge points. The AFW technology would be the same, potentially with aeration supply, while plant collection could be simpler and more focused in to creation of higher biomass, combined with aesthetic function;
- **Smart AFW** with new functions in the future potentially could target new customer segments. It is susceptible for futuristic visionaries. It could be designed to serve as an environmental monitoring platform, and education ground for STEM.

Manufacturing costs

- The production of robust and buoyant custom made AFW can be pricy adventure. But, like in any other industry, tug of war between low cost options vs high-priced modular structures facilitates entire sector growth and creates added value for product end-users. Manufacturing costs (1. materials, 2. labor, 3. all overhead costs) mostly depend on two aspects – how sustainable your approach is and AFW structure itself. Long lasting planet-friendly actions quite often lead to more expensive production costs. Size and technical specs of structure (or technology and design), the other cost defining aspect, specifies resources needed.
- **Materials** – structure needs buoyant solid base, buoyant filling with coating, protective coating cover, plant media. The list of materials possible to use for AFW production: PVA foam, Polyurethane foam (PU), Thermo fused high-density polyethylene (PE), Aluminum and polyurethane closed cell marine foam, UV-resistant LDPE, High density polyethylene (HDPE), Stainless steel & reed stems, Wood & cork.

  The project experimented with two types of custom made AFW: 1. Floating matrix is made out of thermowood. With this thermally modified spruce wood the durability and buoyancy is enhanced and 2. Matrices made of recycled and UV-resistant hollow plastic (HDPE) pipes, covered with coconut coir fiber filled with reed stems (local and free) and fastened using a metal net. The latter costs were twice as high compared to the first one.
- **Labor** - as AFW production still requires man labor and is not produced by mass production in factories, these expenses can be high. Starting AFW from scratch will take you to R&D stage, which is time consuming (thus costly) process. After

material testing and experiments with prototype, process gets faster. For us it took about few months of research and testing, and another few to produce by hand first floating AFW of 24 m2.

- **All other overhead costs** – all indirect material and manufacturing costs including supporting staff costs.
- **Plants** – many options: local or choose not very expensive (local reeds can be even for free) or exotic choices to fancy your AFW. In our project case we used many local plants (good survivors), and in urban areas more exotic ones.
- Brief summary of total manufacturing costs in our project case for one 24 m2 floating AFW prototype: materials 2200 Eur, plants 1000 Eur, labor and only minor overhears included – 3000 Eur. Compared to existing manufacturers in the industry, the costs are lower. Whereas, commercial producers usually sell such isladns for 7000 - 9000 Eur.

Fig. 7. Planting island in Klaipeda City park in 2021.

Market Potential

Presently, AFW construction and design are in the introductory stage. In the SB region, it would compete primarily based on local materials used to produce the floating platform. The future need is to develop plastic-free buoyant technology to meet the sustainability requirements. This technology would unlock the potential of the market significantly. The green technology and sustainability market have increasing potential across EU and especially in SBR, where it is still at the initial stage.

Table 4. Customers / customer profile

Customer Segment	Value Proposition
Government Owned	
Municipalities, public institutions, parks, education centers, schools and universities, museums, cultural heritage visitors centers; touristic centers.	- Environmental quality improvement – water quality and biodiversity restoration; - Aesthetic value and image creation; - Attraction of visitors (tourists) by photo opportunities; - Green technology and sustainability market – reductions of environmental foodprints, coastal cities development projects; - Solutions for coastal erosions and grey-infrastructure dominant shorelines of the rivers and city canals.
Non-Government Owned	
Private owners: restaurants, hotels, rural tourism homesteads Marinas, Sport sites, kiting, surfing centers; Architecture building and real estate developing companies; households;	- Environmental quality improvement – water quality and biodiversity restoration; - Aesthetic value and image creation; - Attraction of visitors.
NGO’s (e.g. Ornithological fishery societies, nature conservation and restoration charity funds).	- Biodiversity restoration – fish and bird habitat creation. - Endangered species habitat creation.

Critical Success Factors in SBR

The environmental context is pretty important in the SBR due to the long-term deteriorated status of the Baltic Sea ecosystem and the commitment of the countries in the catchment to reduce pollution levels. The coastal municipalities are facing the dilemma of industry and port development support and maintenance of good environmental status. Therefore, the green technologies would help to resolve this dilemma by compensating for some biodiversity habitat loss, and loss of landscape aesthetics. The SBR is also known for its Coastal and maritime tourism sector. Local communities have unique opportunities for hobbies, activities, or interests such as sailing, boating, and walking along embankments. So the associated infrastructure could be enriched with green elements such as AFW. Last but not least, the marinas and small port areas formerly used for small fishery boats nowadays remain empty due to fishery collapse in the Baltic Sea. The newly emerged aquatic space in these areas has a high potential for building green infrastructure.

In long-term, the future depopulation rate in the villages of SBR region and continuous migration of inhabitant to the cities will also contribute to increasing demand to improve life quality in the cities.

In conclusion, the regional and national, as well as pan-European environmental policy implementation needs, will act as an important driver for AFW market development.

Fig. 8. Marina in Wolin NP with installed island.

Retention, Distribution channels

The government-owned segments such as municipalities and public institutions could be engaged through ongoing activities and strategies:

- Blue growth initiatives e.g. The Economic Development Strategy of Klaipėda 2030;

- Maritime clusters fostering the Blue Economy in the region;
- National municipalities associations in Green infrastructure development.

Distribution channels:

- Direct sell from the producer to the customers.
- Events & Traveling e.g. exhibitions
- Digital curation: website development, search engine optimization, maintenance, design, and illustration, Social Media (in, tweeter, FB).

Competition, Risks and opportunities

There are no alternatives to AFW. It is unique because it is non-land-based and easy to install and maintain. It has a competitive advantage against other water treatment technologies because of its low initial investment cost and high value of cultural ecosystem services. We do not anticipate that many new companies will enter this market, but a few producers might be established in the SBR market.

The greatest risks associated with AFW business today are increasing costs of manufacturing facilities, production materials, and staff. The research-based and inclusive business would overcome these risks because of participating in R&D projects, and innovation development projects.

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