AQUACOMBINE

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Document history

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0.1	31/03/2020	Charlotte Fonseca Holmene	First draft of deliverable
1.0	31/03/2020	Charlotte Fonseca Holmene	Final editing.

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Table of Contents

1 Executive Summary

This deliverable will describe the AQUACOMBINE website created for external communication about the project and is part of WP12 – Exploitation and Dissemination. It will present the project website for the project: www.aquacombine.eu and will contain a brief description of the website structure and screenshots of the various pages.

The public website is publicly accessible and will serve the purpose of presenting general project information as well as results when generated.

The website will be maintained by AAU on the basis of input from all consortium partners.

2 Introduction

The domaine www.aquacombine.eu has been acquired and a website created for the AQUACOMBINE project with the main purposes of providing information about the project as well as disseminating results and progress to the general public.

The website is publicly accessible with no restrictions, but it includes a link to the consortium's private area (AQUACOMBINE SharePoint) only accessible to consortium members upon request to the coordinator.

3 Website structure

The public website contains a front pages also serving as "home" and the site the reader will be guided to when clicking "home" at the top bar. The front page briefly presents an introduction to the AQUACOMBINE project, the challenges that the project is trying to meet and how the work is structured in work packages. By clicking on each of the WPs 2-12 the reader will be guided directly to a description of the objectives of that individual WP.

All sections of the website presents the AQUACOMBINE logo in the upper left corner and at the bottom a presentation of all partners with logo and link to their individual websites as well as the EU H2020 acknowledgement.

The website is structured as follows:

- Home
    - Links to the project SharePoint
    - Partner logos and link to websites
    - Acknowledgement to European Union's Horizon 2020 and disclaimer
- About
    - Background
    - Objectives
    - Future impacts
    - UN goals
- Results (not activated yet as we have no results to show yet)
    - Public deliverables
    - Publications
- News
    - Newsletters
- Consortium
- Contacts

The sections below will present some screen shots of the website content. The website will be developed continuously as the project progresses and content and sites may evolve and/or change over time.

3.1 Home


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HOME
ABOUT
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THE AQUACOMBINE PROJECT
One of the most important challenges of the 21st century is to meet the world's demand for sustainably produced biomass for both food and the growing bio-products sector. Increased use of fresh water for agriculture and loss of farmland due to salinity are related concerns. Salicornia europaea (S. europaea) is grown commercially in the EU for its fresh tips, which are edible as salad (marsh samphire). It is a halophyte plant and can grow on saline lands without requiring freshwater for irrigation. When grown as a vegetable only the fresh tips are used while the woody part of the plant is considered a residue.
Today, European farmers are using part of the fibrous residue for soil amendment and drying the fibers to produce herbal salt. However, the amount of residue to food product is large (approximately 80%) and the salt content of the residue is a problem when used for soil amendment, as it returns the salt to the soil.
There is a great wish from Salicornia farmers to increase the value of this fraction in line with the principles of circular economy. The woody residue part of Salicornia has been investigated as a source of pharma- and nutraceutical products due to its high content of phytochemicals e.g. hydroxycinnamic acids (HCA). To help increase Salicornia farming there is a wish to valorize these residues via biochemical and bioenergy production.
The project will also examine the combination of aquaculture and Salicornia farming creating synergies such as formulation and test of phyto-chemicals rich functional fish feed and formulation and test of protein and lipids rich fish feed. The outcomes of this study will enable Salicornia farmers and aquaponics farms to utilize all fractions of the produced biomass and produce value added HCAs, functional fish feed and bioenergy. This will create a new circular industries with co-production of food, pharma, and bioenergy from this new sustainable type of crop with very little or no production of waste streams.
WP1: Project coordination
WP2: Halophyte cultivation
Extraction, fractionation, and purification WPs:
WP3: Develop optimised extraction methods for lignified biomass
WP4: Purification and stabilisation of extracted HCAs
WP5: Develop optimised extraction methods for green biomass
WP6: Chemical and bioactivities analysis
Products formation WPs:
WP7: Fish feed formulation and testing
WP8: Cosmetics and Dairy products formulation and testing
WP9: Biogas and activated char coal production
WP10: Techno-economic analysis and business plan
WP11: Demonstration plant construction and tests
WP12: Exploitation and dissemination

Logos and EU acknowledgement at the bottom of each page:

Acknowledgement

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3.2 Background

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BACKGROUND

Soil salinity has been reported as a major factor to farm land degradation. About 6.7 million hectares are considered salt affected and 72 million hectare are considered sodic in EU[1]. This is twice the area of Germany. The major threats are along coastal areas in the south where intensive use of saline agricultural water is leading to desertification. An EU ComCoast study emphasized the risk in Northern EU countries by sea level rise, that salt intrusion is threatening the coastal areas[2]. In many instances, irrigation causes an increase in soil salinity due to overirrigation of agricultural land, inefficient water use and poor drainage of unsuitable soils. Most known agricultural crop plants are salt-sensitive glycophytes, of which, the growth is severely inhibited when grown under saline conditions. Therefore, these plants cannot be produced economically in salinized soils or with saline water. The United States Department of Agriculture estimates that, worldwide, 10 million hectares of arable land are lost every year to salinity as a result of improper irrigation[3]. 24 % of globally usable land on Earth is degraded at an estimated economic loss of 490 USD billion per year[4]. This is a global and European challenge that needs to be addressed and this challenge will become increasingly demanding in order to meet the expected demand of 50% more food, 40% more energy, and 30% more water by 2030[5] [6] [7].

Halophytes are plants that are salt tolerant and can grow in saline soils and/or be irrigated with seawater. Haophytes e.g. *Crithmum maritimum, Portulaca oleracea, Salicornia spp. and Aster tripolium* have been consumed by humans for centuries, and are still often gathered from the coastal salt marshes and inland salt pans of Europe. These species are well known for their ability to synthesize high concentration of bioactive secondary metabolites. Hence, this type of vegetables give a high potential for co-production of food and bioactive compounds. A range of cultivation systems for the utilization of halophytes have been developed and commercialized, for the cultivation of gourmet vegetables and purification of saline effluent (e.g. aquaculture effluents).

The secondary metabolites in halophytes include simple and complex sugars, amino acids, quaternary ammonium compounds, polyols and antioxidants (e.g. polyphenols, b-carotene, ascorbic acid and ureides)[8] [9] [10] [11]. These compounds can potentially be utilized in functional food, which is defined as having disease-preventing and/or health-promoting benefits. The modern awareness of a healthier diet promotes additional markets for halophytes with high nutritional potential, evident in the rapidly growing consumption of products from some halophytic plants (e.g. Salicornia and quinoa)[12].

In the AQUACOMBINE project we aim to **demonstrate combined aquaculture and halophyte farming (farming of saline tolerant plants) using the principles of circular economy, where waste is recovered and utilised with-in the system to create both internal value and new products, beside avoiding the wastes. Residues are utilised with-in the system to create both internal value and new products.** Excess nutrients from the fish production will be used as fertiliser for the halophyte plants and filtered through a microbial water treatment system to enable recirculation of the water back into the aquaculture tanks. All parts of the halophyte biomass will be used for production of multiple products such as food, **feed, botanical extracts and pure bioactive compounds,** as well as biogas from the final residues to produce energy and a nutrient rich residue to bring essential nutrients (e.g. phosphates) back to farmland. This combined aquaculture, farming, and bioprocessing can help desalinize salt **affected areas and can easily be combined with sustainable management of natural areas and/or use of marginal lands to create value and jobs in rual, remote and salt affected and areas.** The bioprocessing will create added value to the combined farming and diversify products.

As the advantages of halophyte agriculture is very clear – in terms of utilization of marginal lands – producing health promoting foods – and for bioremediation of saline soils and/or aquaculture effluents there are challenges, which are preventing implementation on a larger scale.

With the proof for greenhouse cultivation and mechanical harvest the use of halophytes as sea vegetables has seen a steady growth in countries like Great Britain, France and the Netherlands. *Salicornia europaea* L. is used for sea vegetable production. This cultivation requires a high seed density per square meter (2-4g/m2, depending on season). The sowing starts early March till end of April. This offers the opportunity to harvest vegetable from June till end of August. At this stage young fresh tips can be offered. Once the switch in photoperiodicity (mid of September) the plants starts lignifying slowly. From measurements the *Salicornia europaea* (Sea asparagus/Marsh samphire) crop built up two thirds of its total biomass in the period September – end October/beginning of November. In the first 2 weeks in September the green tips are still very succulent but worthless as vegetable and offers possibilities for fresh plant extracts. Stage 3 can be described as flower initiation and first seed setting. A final stage is seed ripening and die off of the crop. *S. bigelovii* has a different photoperiodical strategy. From previous experiments, we noticed that *S. bigelovii* remains vegetative as temperatures remain below 20 degrees.

We must evaluate this feature in terms of a Northern European Salicornia production. Growers could benefit from the valorization of the residue biomass of their cultivated sea vegetables through a longer cultivation period. Intermediate crops will help in keeping the saline soils in shape to cover these soils over a longer period. Hence, in the AQUACOMBINE project, we aim at valorizing the non-food part of the halophyte biomass in terms of non-food applications, and indirect food applications e.g. by aquaculture feed production.

The valorization of the non-food part of the biomass as presented in the AQUA-COMBINE project will be essential in catalyzing new European halophyte businesses.

3.3 Objectives

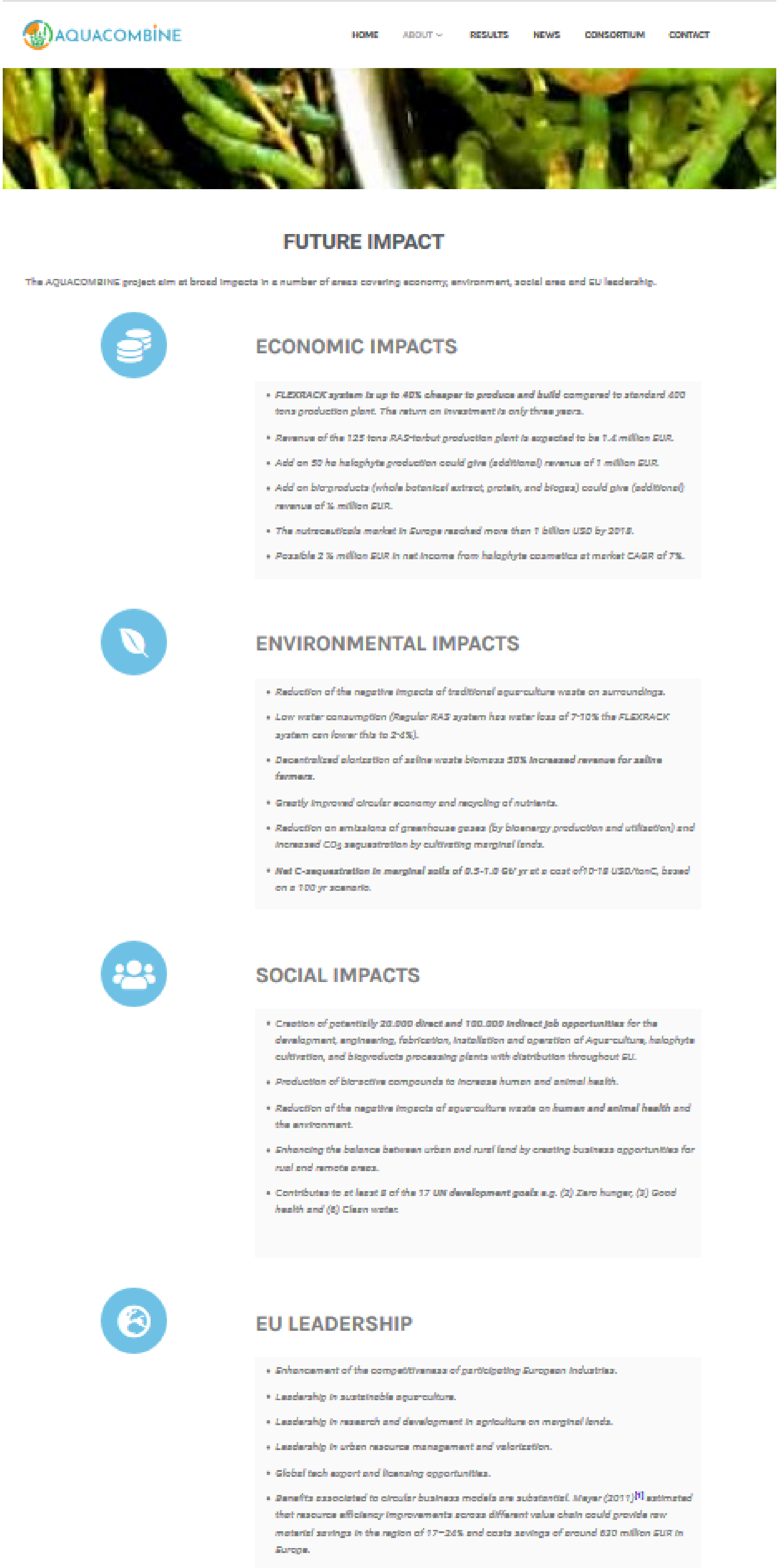
OBJECTIVES

In the AQUACOMBINE project we aim to demonstrate combined aquaculture and halophyte farming (farming of saline tolerant plants) using the principles of circular economy, where waste is recovered and utilised within the system to create both internal value and new products, beside avoiding the wastes. Residues are utilised within the system to create both internal value and new products.

Excess nutrients from the fish production will be used as fertiliser for the halophyte plants and filtered through a microbial water treatment system to enable recirculation of the water back into the aquaculture tanks. All parts of the halophyte biomass will be used for production of multiple products such as food, feed, botanical extracts and pure bioactive compounds, as well as biogas from the final residues to produce energy and a nutrient rich residue to bring essential nutrients (e.g. phosphates) back to farmland.

This combined aquaculture, farming, and bioprocessing can help desalinize salt effected areas and can easily be combined with sustainable management of natural areas and/or use of marginal lands to create value and jobs in rural, remote and salt effected areas. The bioprocessing will created added value to the combined farming and diversify products.

3.4 Future Impact



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FUTURE IMPACT

The AQUACOMBINE project aim at broad impacts in a number of areas covering economy, environment, social area and EU leadership.

ECONOMIC IMPACTS

- *FLEXRACK system is up to 40% cheaper to produce and build compared to standard 400 tons production plant. The return on investment is only three years.*
- *Revenue of the 125 tons RAS-turbot production plant is expected to be 1.4 million EUR.*
- *Add on 50 ha halophyte production could give (additional) revenue of 1 million EUR.*
- *Add on bio-products (whole botanical extract, protein, and biogas) could give (additional) revenue of ½ million EUR.*
- *The nutraceuticals market in Europe reached more than 1 billion USD by 2018.*
- *Possible 2 ½ million EUR in net income from halophyte cosmetics at market CAGR of 7%.*

ENVIRONMENTAL IMPACTS

- *Reduction of the negative impacts of traditional aqua-culture waste on surroundings.*
- *Low water consumption (Regular RAS system has water loss of 7-10% the FLEXRACK system can lower this to 2-4%).*
- *Decentralized alorization of saline waste biomass 50% increased revenue for saline farmers.*
- *Greatly improved circular economy and recycling of nutrients.*
- *Reduction on emissions of greenhouse gases (by bioenergy production and utilisation) and increased CO_2 sequestration by cultivating marginal lands.*
- *Net C-sequestration in marginal soils of 0.5-1.0 Gt/ yr at a cost of10-18 USD/tonC, based on a 100 yr scenario.*

SOCIAL IMPACTS

- *Creation of potentially 20.000 direct and 100.000 indirect job opportunities for the development, engineering, fabrication, installation and operation of Aqua-culture, halophyte cultivation, and bioproducts processing plants with distribution throughout EU.*
- *Production of bioactive compounds to increase human and animal health.*
- *Reduction of the negative impacts of aqua-culture waste on human and animal health and the environment.*
- *Enhancing the balance between urban and rural land by creating business opportunities for rual and remote areas.*
- *Contributes to at least 8 of the 17 UN development goals e.g. (2) Zero hunger, (3) Good health and (6) Clean water.*

EU LEADERSHIP

- *Enhancement of the competitiveness of participating European industries.*
- *Leadership in sustainable aqua-culture.*
- *Leadership in research and development in agriculture on marginal lands.*
- *Leadership in urban resource management and valorization.*
- *Global tech export and licensing opportunities.*
- *Benefits associated to circular business models are substantial. Meyer (2011)[1] estimated that resource efficiency improvements across different value chain could provide raw material savings in the region of 17–24% and costs savings of around 630 million EUR in Europe.*

3.5 UN goals

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UN SUSTAINABLE DEVELOPMENT GOALS

The Water-Energy-Food nexus has been central in discussions on sustainable development[1]. Socioeconomic development and population growth pose unique challenges in securing sufficient water, energy, and food. These challenges will become increasingly demanding in order to meet the expected demand of 50% more food, 40% more energy, and 30% more water by 2030[2] [3] [4]. More than 2 billion people are living with the risk of reduced access to freshwater resources and by 2050, at least one in four people is likely to live in a country affected by chronic or recurring shortages of fresh water[5]. Clean water for all is one of the 17 UN development goals, with one of the targets being to substantially increase water-use efficiency across all sectors. Agriculture is the largest user of freshwater, which is essential for food production, but also for biochemical and biofuels production, as we are moving towards a bio-based society. Hence, lack of fresh water and salinization of soils are at the core of the Water-Energy-Food nexus and represents major challenges to meet several of the 17 UN development goals. Sustainable Aquaculture and halophyte farming development – like suggested in the AQUACOMBINE project – could directly contribute to meeting goals: (2) Zero hunger, (3) Good health and wellbeing, (6) Clean water, (7) Affordable and clean energy, (8) Decent work and economic growth, (9) Industry, innovation, and infrastructure, (12) Responsible production and consumption, (14) Life below water, (15) Life on land (Figure 15).

SUSTAINABLE DEVELOPMENT GOALS

Figure 15. 17 UN sustainable development goals[6].

More than 98 percent of the application of halophytes can be found in the use as food: fresh cuttings and pickling. Halophyte are old medicinal plants and offer health benefits that are highly sought after in today's society, where consumption of purpose bred crops and refined food are causing an epidemic in lifestyle diseases. Lifestyle-related diseases are now the leading cause of death worldwide, killing 36 million people a year. The cumulative costs of heart diseases, chronic respiratory diseases, cancer and diabetes in poorer countries are expected to top 7 trillion USD (4.4 trillion GBP) in 2011-2025, an average of nearly 500 billion USD (316 billion GBP) a year, according to the World Economic Forum. The phytochemicals in halophytes offer anti-inflammatory, anti-microbial, and anti-diabetic properties, as well as protection against cancer and cardiovascular problems, which can help relieve life style diseases, and diversity our consumption patterns away from heavily processed and low nutrition foods. As halophyte farming can be done in various scale and for various purpose; both as a healthy food source and as biomass for biorefining, evolving this technology has great potential to boost growth and employment in coastal areas even in areas with low quality soils and arid environments.

3.6 Consortium

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CONSORTIUM

AQUACOMBINE (Integrated on-farm Aquaponics systems for co-production of fish, halophyte vegetables, bioactive compounds, and bioenergy) is a consortium of 17 European partners coordinated by Aalborg University. The project started in October 2019 and will run for four years.

The partners involved are:

AALBORG UNIVERSITY

AALBORG UNIVERSITY
DENMARK

Is the project coordinator and lead in WP1, 3, 6, 12 and 13. AAU will develop optimised extraction methods for bioactive compounds in lignified biomass. AAU will also identify the chemicals and analyse the bio-activity of halophyte extract fractions and isolate the pure components. CEL assist in optimizing the extraction processes at pilot scale. Throughout all the work packages AAU will collaborate will all partners.

The AAU team consists of:

- Mette Hedegaard Thomsen, Associate Professor and project coordinator
- Marco Maschietti, Associate Professor
- Allan Stensballe, Associate Professor
- Charlotte Fonseca Holmens, administrative project manager

LULEÅ
TEKNISKA
UNIVERSITET

LULEA TEKNISKA UNIVERSITET

Will be leading WP4, where they will develop methods for purification and stabilisation of HCAs.

The LTU team consists of:

- Paul Christakopoulos, Chair Professor
- Ulrika Rova, Professor
- Leonidas Matsakas, Associate senior lecturer
- Io Antonopoulou, PhD

GOTTFRIED WILHELM LEIBNIZ UNIVERSITÄT HANNOVER

Leibniz
Universität
Hannover

LUH will leverage their expertise in studying the physiological status of plants and analyse halophyte cultivation patterns. They will lead WP2. RSR and LDM will also provide support and collaboration to LUH in growing Salicornia Europaea.

The LUH team consists of:

- Jutta Papenbrock, Dr. rer. nat., Professor
- Johann Hornbacher, Master of Science

3.7 Contact


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CONTACT INFO
Please contact our project coordinator if you want to learn more about the AQUACOMBINE project:
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