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## Can the microalga market be long term? A company perspective

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**Abstract:** This research combines the investigation on the contributions of the AlgoSolis laboratory in the development of innovations, emerging new fields and start-ups and the analysis of LLDC Algae, a company located in the West of France. Using both point of view will help to understand the opportunities and threats, as well as the key factors of success in the microalga market.

This research objective is to present the resources conditions and the necessary expertise to develop microalga transformation for different markets, to support a sustainable agriculture.

Two industrial applications seem to be more promising in our context of renewal solutions to support a low environmental impact: greenfeed for the animal feeding and green crops that propose crop supplements based on microalga. The company LLDC Algae targets the needs of both markets thanks to its expertise and to the high-performance proposal compared to traditional solutions.

We are looking for the adopters' factors to increase the implementation of these solutions.

**Key words:** *microalga, innovation, sustainable agriculture, case study*

## 1. Introduction

Microalgae are unicellular microorganisms found in aquatic environments. They are a sustainable source of biomass rich in nutrients such as proteins, lipids, vitamins and antioxidants. The microalgae market is growing rapidly, driven by increasing demand for healthy, sustainable food ingredients: they are widely considered to be one of the most environmentally and economically promising natural resources. Certain species of microalgae have extremely rapid growth rates. With an estimated number of 30,000–1,000,000 species, microalgae represent an exceptional natural resource to explore for the 21st century that combines numerous advantages, such as original metabolisms and chemical compositions, fast growth, high photosynthetic efficiency, non-competition for farmlands and tolerance to wastewaters during cultivation (Rumin et al., 2020).

They can convert CO<sub>2</sub> into a variety of value-added products. Microalgae are highly interesting microorganisms for CO<sub>2</sub> capture due to their efficient photosynthetic capabilities, rapid conversion of this gas into biomass, and ability to grow without the need for agricultural land. In addition, wastewater treatment and the production of value-added components, raw materials for aquaculture, and environmentally friendly and sustainable biofuels can also be achieved using microalgae cultures for CO<sub>2</sub> capture. Finally, the energy and economic costs of implementing this technique are low compared to other techniques currently being investigated. This makes the use of microalgae an even more attractive option for reducing atmospheric CO<sub>2</sub> levels and slowing global warming. Microalgae biotechnology is taking part to the global economy by processing valuable biomass for human-related utilisations (Fernández et al., 2021), such as bioplastic production (Chong et al., 2022), bio energies (Chong et al., 2021, Wang et al., 2021), and environmental monitoring (Peter et al., 2021). Microalgae can enrich considerably the bio economy (Fernández et al., 2021, Yong et al., 2021) thanks to the development of existing processing capability and to the proposal of new applications.

The total microalgae market is estimated to reach USD 4.6 billion by the year 2027 (Show, 2022).

This is due to the increasing awareness of the valuable functional compounds possessed by microalgae and the benefits they can provide in terms of sustainability compared to current methods of food or energy production<sup>1</sup>. Therefore, this promotes the awareness of using microalgae biofuel as an enormous potential to displace or even replace the \$2.1 trillion fossil fuel industry (Curtin et al., 2019). Microalgae have also been introduced as a source of biofertilizer processing, biochemicals, and biochar for wastewater treatment (Khoo et al., 2021). It has many uses and can suit a wide range of industries, making it a highly valuable resource. Currently, the microalgae market seems to offer potentials, but stay with a limited number of players. We will try to answer to the following questions, as they may lead to a better understanding of the existing context. What are the opportunities and threats in the microalgae market and can be game changing? What are the key variables for the Green Crops Business Unit in the macro-environment?

It is necessary to design an economic model adapted to take both advantages of, first, technical innovation in agronomy and animal husbandry to improve yields by around 20%, and on reducing losses and waste to increase production by an additional 10 to 20% (Rastoin,

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<sup>1</sup> Wood, L. (Éd.). (2022, 17 janvier). Global Microalgae Market Trajectory & Analytics Report 2022: Robust outlook for Nutraceuticals Strengthened by pandemic induced focus on immunity Drives Opportunities for Algae - ResearchAndMarkets.com. Business Wire. <https://www.businesswire.com>, le 21/05/2024

2016)<sup>2</sup>. To help the development of economic viable models, we need to get some information and answer to the following questions. What are the Success Key Factors that can have an impact on the profitability? How the constraints and operation of the industrial process, optimization and limits of application, potential for exploitation can influence the sector?

“Biofertilizer” is a substance that contains living microorganisms that, when applied to seed, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant (Ritika et Utpal, 2014). *Chlorella* sp. was revealed to increase about 30% the wheat plant length, so it could be proposed as a probable substitute to chemical fertilizers to rise soil fertility (Rumin et al., 2020).

LLDC Algae seems to have solved a major problem, namely low sun exposure, by combining the production of microalgae with earthworm digestate. This market is still in its infancy, although yields from vegetable and wine crops are very encouraging. Numerous patents protect its industrial activities. How the case study of a company highlights major characteristics of the environment and propose management and collective interest recommendations?

This paper objective is to present a new combination of technologies implemented by a French local company that proposes a range of bio fertilizers. The adoption of such products may induce a game changing in the market, as the European regulations push farmers to use healthier agricultural practices to help the development of a more sustainable agriculture.

In this article, we will present a market analysis giving the key variables for the Green Crops Business Unit and the Success Key Factors for players. It will be followed by the methodology used to present the company and its data. We will conclude this paper by proposed recommendations.

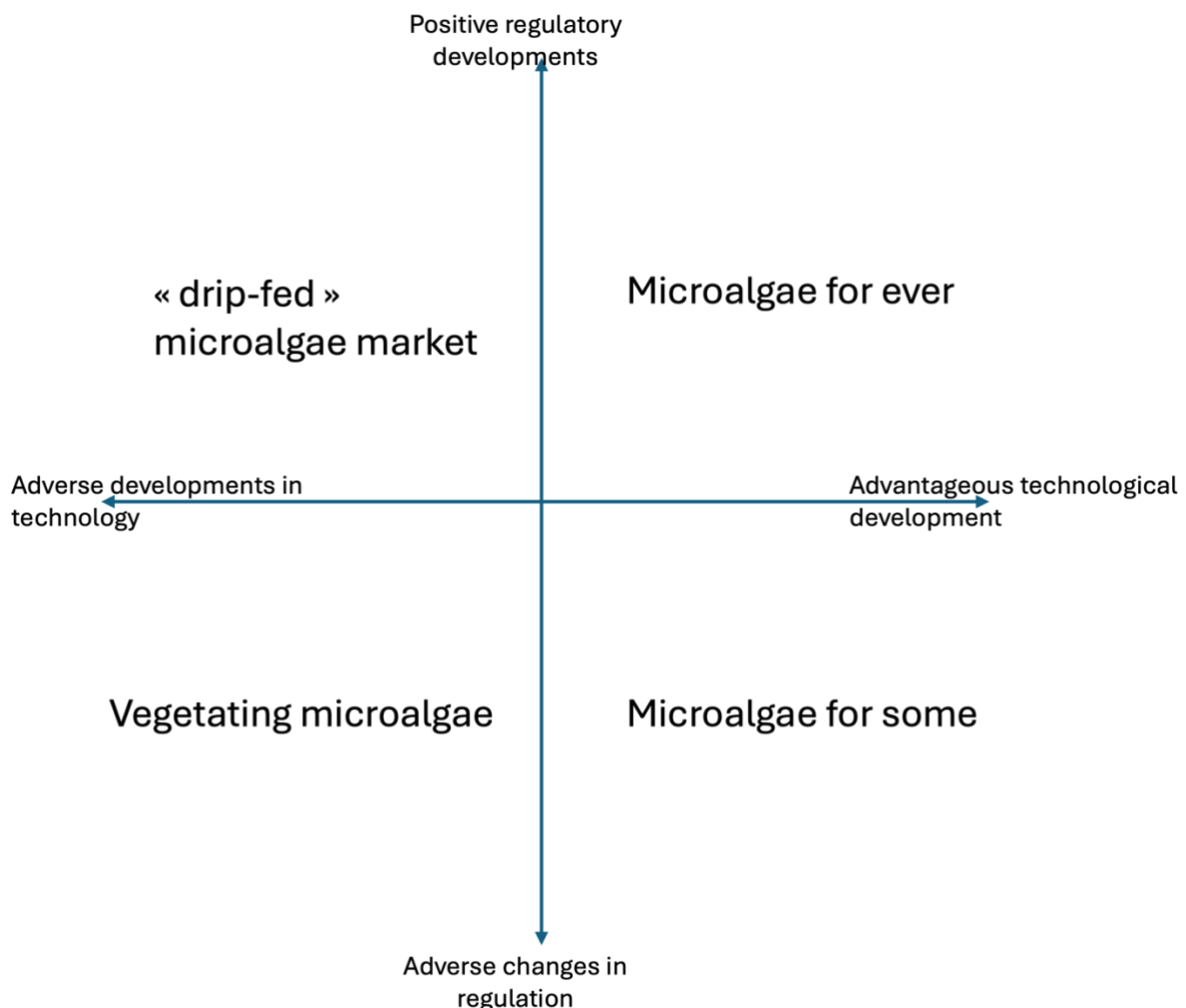
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<sup>2</sup> Le secteur des micro-algues en Méditerranée. IPAMED, études et analyses., le 19/04/2024

## 2. Background and market analysis of microalgae

### 2.1 Analysis of the macro-environment and identification of key variables for the Green Crops Business Unit

Assessing the economic viability of models based on microalgae cultivation can be challenging due to the technical nature of culture selection, the diversity of applications in different markets and the type of algae used. Based on the idea that the yields obtained from micro-algae are comparable to those obtained from other solutions for supporting agricultural productivity, the analysis suggests that the large-scale development of micro-algae farming for agricultural purposes is dependent on two uncertain variables: public regulatory support, and the potential for significant technological advancement. Relying on the market for soil fertilization only, we can shape this diagram to evaluate long-term options for this market. The scenario method (Reynaud, 2001) can identify two crucial variables for designing long-term objectives in an uncertain future.



**Figure 1:** projection diagram using scenario method

The decrease of water supply in some geographic areas, due to climate change, combine with the global population increase are generating a water crisis that encourages the research on plant nutrition and innovative bio fertilizers, where the microalgae-based bio fertilizers appear as a realistic alternative of nutrients for crops (Rumin et al., 2020).

Tripathi et al. (2008) studied the integrated use of blue green algae bio fertilizer in the rice culture. They concluded that it has a positive impact on stress, growth, yield and mineral composition of the rice plants, and helps to reduce the high demand of nitrogen fertilizers.

Climate change is expected to intensify the existing risks for agricultural water management under climate change in Europe, particularly in regions where water scarcity is already a concern (Iglesias & Garrote, 2015). The climate change in Europe clearly encourages new solutions to save water consumption, so bio fertilizers could be one of the answers. The next part will list the major points to be lucrative.

## 2.2 Market overview, analysis of the profitability (Porter, 1985) and the sector strategic question (current Success Key Factors)

The following figures illustrate the market potential. However, it is important to consider the limitations of the factors to ascertain the existing profitability:

- European production of microalgae represents around 0.3 million tonnes, or 0.57% of world production in 2016 (33 million tonnes<sup>3</sup>).
- The European microalgae market generated a turnover of around €750 million in 2018<sup>4</sup>.
- There were 126 companies producing microalgae in the EU in 2019<sup>5</sup>.
- The European microalgae market is expected to grow at an annual rate of 6.4% by 2025<sup>1</sup>.

While the technological developments and areas for improvement in the conversion of microalgae into fertilizers appear to be well under control (Osorio-Reyes et al., 2023), it is important to identify when the sector can become profitable, considering experience and economies of scale to anticipate future developments. The information can be approached by identifying key elements from the market.

Market entry barriers are our first point:

- High levels of capital investment in the construction of production units<sup>6</sup>
- Limited access to microalgae strains and production technologies<sup>7</sup>
- Economies of scale achieved by established operators<sup>8</sup>

Secondly, the threat from substitutes is from other plant protein sources. The question of the best solution for healthy and sustainable development is not being fully addressed today: the solutions are still in competition.

Within the industrial sector, there are few suppliers of microalgae strains and specialized equipment. The core of the industry is dependent on input suppliers of nutrients, CO<sub>2</sub>, etc. Clients represent a fragmented market with many small players as market gardeners and cereal growers, whose bargaining power tends to grow as their demand for healthy, natural products increases<sup>9</sup>. Support industries for the microalgae sector include suppliers of production equipment (photo bioreactors, harvesting systems), specialized research centres and universities<sup>10</sup>, and certification and quality control bodies.

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<sup>3</sup> <https://sensalg.fr/la-production-dalgues-en-europe-et-la-culture-en-france/>

<sup>4</sup> <https://www.greatitalianfoodtrade.it/fr/march%C3%A9s/la-commission-europ%C3%A9enne-propose-23-actions-pour-la-fili%C3%A8re-algues/>

<sup>5</sup> <https://sensalg.fr/la-production-dalgues-en-europe-et-la-culture-en-france/>

<sup>6</sup> [https://www.ipemed.coop/imgedit/IPEMED\\_Etudes%20et%20Analyses\\_Rapport%20microalgues.pdf](https://www.ipemed.coop/imgedit/IPEMED_Etudes%20et%20Analyses_Rapport%20microalgues.pdf)

<sup>7</sup> <https://sensalg.fr/les-microalgues-dans-la-zone-atlantique-europeenne>

<sup>8</sup> <https://elitepharm.fr/actualites/les-algues-et-microalgues-un-marche-en-pleine-expansion>

<sup>9</sup> <https://pepswork.com/2020/08/13/agroalimentaire-micro-algues-marche-croissance/>

<sup>10</sup> <https://sensalg.fr/les-microalgues-dans-la-zone-atlantique-europeenne>

Three main strategic groups can be identified in the microalgae market:

1. The major food and chemical groups (Cargill, DSM, BASF), which are investing in microalgae to diversify their activities<sup>11</sup>.
2. Companies specializing in large-scale production of microalgae (Cyanotech, Algaenovo, Algalif, Olmix)<sup>12 13</sup>.
3. Start-ups and SMEs focusing on niche applications

As compared to photo bioreactors, open raceways (especially with wastewater) are more effective for small capital investments and low power consumption in a large-scale production algal biomass.

The critical point, that was shown in many studies, is the economically feasible of algal production (Win et al., 2018).

For Costa et al. (2019), the economic viability of a bio refinery implies some key decisions, such as a substantial reduction of the current operating costs, using low-cost inputs, and maximizing the automated work for upstream processes.

Today, rivalry between companies in the sector is building and is already sensitive to differentiation strategies based on strains and production processes<sup>1</sup>, while cost competition is starting to emerge for certain mass applications<sup>1</sup>, rapidly leading to market consolidation through mergers and acquisitions<sup>14</sup>.

In conclusion, the key success factors today are:

- Mastery of large-scale production technologies
- Access to high-performance strains of micro-algae
- Capacity for innovation to develop new products
- Compliance with food and environmental regulations
- Positioning in high added-value segments (nutraceuticals, cosmetics)
- Partnerships with key players in the value chain<sup>1 15</sup>.

After defining the key success factors, we will detail the obstacles, the optimizations and limits in the industrial process.

### 2.3 Analysis of the sector: constraints and operation of the industrial process, optimization and limits of application, potential for exploitation

As the industrial process can encourage or limit the business development, it is central to define these parameters.

Microalgae have capacity for CO<sub>2</sub>-fixation, so can have a significant impact to sustain earth's ecosystems and can play a role, but still underestimated in eliminating contaminants from various environments (Koller et al., 2014, Chaturvedi et Kumar, 2016).

#### 2.3.1 Soil constraints for agricultural use

Several studies highlighted some limitations for cyanobacterial bio fertilizers in areas possibly contaminated by pesticide residues, herbicides residues, and heavy metals (i.e., nickel and copper), or in land with high salinity (He et al., 2013, Yadav et al., 2016). The salinity can

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<sup>11</sup> <https://www.place-publique.fr/index.php/environnement/le-secteur-des-micro-algues-en>

<sup>12</sup> <https://pepswork.com/2021/05/04/le-marche-des-algues-un-secteur-dinnovation-pour-les-marques-food/>

<sup>13</sup> <https://olmix.com/about/>

<sup>14</sup> <https://www.theinsightpartners.com/fr/reports/microalgae-based-products-market>

<sup>15</sup> <https://www.greatitalianfoodtrade.it/fr/march%C3%A9s/analyse-de-sc%C3%A9narios-sur-les-microalgues-et-la-bio%C3%A9conomie-bleue-en-Europe>

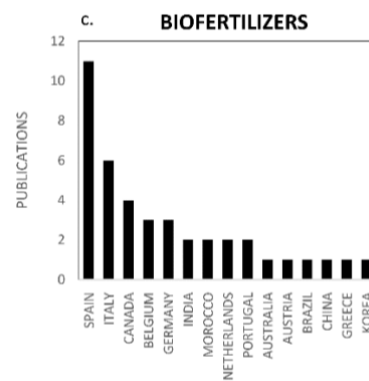
modify the physiological attributes, antioxidant enzymes, and nitrogen fixing activity (Yadav and al., 2016). He et al. (2013) demonstrated that high concentration of butachlor could affect the growth, the photosynthesis activity, add stress in nitrogen-fixing cyanobacteria and induce an algae adaptive strategy.

Debnath et al. (2011) studied the effects of usually used pesticide, fungicide, and insecticide on the growth and enzymes production of four cyanobacterial species—*Nostoc ellipsoforum*, *Scytonema simplex*, *Tolypothrix tenuis*, and *Westiellopsis prolifica*. The results showed both the fungicides and insecticides at EC50 concentration would cause an inhibitory influence on the expression of nitrogenase and glutamine synthetase (GS) in all four cyanobacterial species studied.

### 2.3.2 Lack of Studies and information to farmers

Despite the advantages of bio-fertilizer application, the lack of awareness and knowledge in the farmers and the local level with very low production rate of algal bio-fertilizer production encounters delay in use in India (Chaturvedi et Kumar, 2016). Governments and federal agencies should promote the use of biofertilizers as eco-friendly alternatives for crop improvement (Basu et al., 2021). Basu et al. (2021) also concluded in their study that a mass public awareness is required to educate the farmers and consumers alike on the advantages of using microbe-based biofertilizers for ensuring a greener tomorrow.

Rumin et al. (2020) analyzed a corpus of 79,020 publications by authors affiliated to research institutions worldwide, especially focused on Europe and in the European Atlantic Area and containing the keywords “microalga(e)” or “phytoplankton”. Biofertilizers is one of the six major markets opportunities highlighted. The number of publications that review and study microalgae-based biofertilizers has increased in recent years and the two main countries publishing in this topic were Spain and Italy (Rumin et al., 2020). France is not listed in the hereunder table presenting the Scientific production by country for the emerging markets of biofertilizers (c).



**Figure 2:** Number of publications on biofertilizer use by country in 2020

Source Rumin et al. (2020, p.23)

Win et al. (2018) explained that the biomass short shelf life and need for expensive cold storage can limit the development of microalgae-based biofertilizers.

Silva et De Jesús Silva (2013) analysed that the viability preservation of the dried and milled biomass was greatly enhanced using halogen lamps and subsequent ionic flocculation. Moreover, they also suggested to add akinetes as a biofertilizer after drying processes, as they have a positive impact on the storage (last several weeks when in a dried state).

Renuka et al. (2015) evaluated different formulations of a biofertilizer (after mixing with vermiculite/compost as a carrier) in wheat crop under controlled conditions. The results showed a significant increase of roots, shoots, and grains (up to 3.56 % in grains observed)



and at harvest stage, a 7.4–33 % growth in plant dry weight and up to 10 % in spike weight. Renuka et al. (2015) concluded that a positive relationship existed between soil nutrient availability at midcrop stage and plant biometrical parameters at harvest stage. This research showed that the use of a biofertilizer mixed with vermiculite/compost as a carrier improved yields of wheat crop.

The growth of algae largely depends on the temperature and pH (Chaturvedi et Kumar, 2016). Silva et De Jesús Silva (2013) proposed an easy method to ensure a high germination rate by applying Cyanobacterial preservation either by air drying or drying wet Blue Green Algae (BGA) in oven at 35–40 C for 24 h in dark.

On an economic part, Chanda et al. (2024) calculated that the use of plant nutrients through cyanobacteria biofertilizers, compared to the application synthetic fertilizers, will decrease the production cost by 12 to 15%. They also showed that the application of cyanobacteria biofertilizers can replace chemical fertilizers without any crop yield loss, help growers generate high value organic okra and stay competitive in the market. The costs for expensive organic Fe growers can be reduced as the Cyanobacteria biofertilizers can provide 2000 ppm of Fe in the soil (Chanda et al., 2024). Cyanobacteria can compensate about 50 % of recommended doses of N, P, and K (Hegazi. et al., 2010).

Algal inoculation in small quantity requires culturing in a growth media in laboratory, but for large scale commercial it may be little expensive, as for paddy fields no additional inoculation is required since once applied in paddy field it replicates in its own (Hegazi. et al., 2010). Based on different reports in the literature, Win & al. (2018) conclude that the carrier-based formulation is more suitable for N<sub>2</sub> fixing fertilizer and soil conditioning, while foliar-based formulation is more appropriate for germination promoting effects. However, as Chaturvedi et Kumar (2016) explained, the commercial utilization of N<sub>2</sub>-fixing organisms in agriculture has met some difficulties. Factors such as a suitable carrier for individual algal, soil, and climate factors and biotic and abiotic stress in the field are the main constraints for commercial use of algae as biofertilizer. Therefore, it is better to apply new methods to produce cyanobacterial mutants to discover a wider prospective of cyanobacteria (Gupta et al., 2013). Sharma et al. (2010) highlighted the prerequisite to implement multidisciplinary approaches with a multiproduct process (bio refinery) plan to optimize the benefit of cyanobacteria.

In the light of this market analysis, we question the sustainability of a business model in this context.

## **Is it possible to use microalgae to develop a sustainable business based on more virtuous products for agriculture?**

The study of the microalgae economic environment will help to appreciate the study of LLDC Algae, that we will analyse in the following part.

### 3. Methodology of the presentation of the company and the data used

The study of the company LLDC Algae is including the analyse of videos, texts and the results published on the website and on the internet.

In 2008, L'Oréal asked one of its Chinese companies to replace palm oil in cosmetics. Microalgae, such as Chlorella, develops through the phenomenon of photosynthesis and was studied for a long time. It explains why LLDC Algae founder wanted to use this micro-organism. They needed to find an area capable of both supplying the energy-generating methanation unit and representing a consumption basin. Central Brittany (Loudéac) was chosen to use the waste of the agricultural production, where microalgae are still considered as pollution, but not as a potential resource<sup>16</sup>.

Started end of 2012, LLDC Algae is a limited liability company with a share capital of 1 000 000€<sup>17</sup>. The financial report shows that the turnover and the subsidies are not covering the investments. However, in 5 years, the turnover increased of more than 150%. In 2021, the company started to get subsidised by the government for the first time. As the company director explained, this project is an opportunity to create a future activity that cannot be relocated and is ecologically virtuous. In 2021, the main shareholder has accepted a debt write-off with a return to better fortunes clause.

The concept proposed by LLDC Algae is based on the effluents from nearby livestock farms, which is sanitised and then digested by the methanizer. The methanation unit produces:

- Energy (heat, biogas, electricity) used by the site, with surplus energy returned to the grid,
- Water purified by water hyacinths and used by earthworms and chlorella culture,
- Digestate (solid residue) mixed with green waste and transformed by earthworms:
  - o Percolat (liquid residue from vermiculture) is a powerful natural fertilizer
  - o Humus (solid residue from vermiculture) is spread on the soil at the time of sowing
- The chlorella is grown in transparent tubes using heat and water from the methanizer and purified rainwater<sup>18</sup>.

The production site has been designed to preserving the environment. The methanizer will produce electricity 4 times more electricity than is consumed on site. The methanizer's electrical generators (co-generation) will heat the cultivation of microalgae, as it requires additional heat, even in a temperate climate. The microalgae will absorb all the CO<sub>2</sub> produced on site. In the end, ecological impact of the site will be positive<sup>19</sup>.

LLDC Algae is producing chlorella that must be consumed fresh with a limited shelf life (3 weeks) once removed from its culture medium and analysed. However, at each stage comes a natural product adapted to the soil, the plant, the animal, and the human<sup>20</sup>.

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<sup>16</sup>LLDC Algae : la plus grande ferme de micro algues d'Europe est à Plouguenast (22). (2021, août 23). Bretagne Prospective. <https://www.bretagne-prospective.bzh/actualites/lldc-algae-la-plus-grande-ferme-de-micro-algues-deurope-est-a-plouguenast-22/>

<sup>17</sup> <https://www.pappers.fr/entreprise/lldc-algae-la-lande-du-cran-algae-789064037>

<sup>18</sup> <https://www.ldc-algae.com>

<sup>19</sup> <https://www.ldc-algae.com>

<sup>20</sup>LLDC Algae : la plus grande ferme de micro algues d'Europe est à Plouguenast (22). (2021, août 23). Bretagne Prospective. <https://www.bretagne-prospective.bzh/actualites/lldc-algae-la-plus-grande-ferme-de-micro-algues-deurope-est-a-plouguenast-22/>

The growth of the business model depends on the French government, which must give its approval. For example, a prefectural decree authorises the use of 160,000 tonnes of inputs (mainly livestock effluent), which will help to turn some 5,000 hectares of waste into humus. Methanisation and the rules for the storage and use of the waste are regulated by the State<sup>21</sup>.

The liquid fraction of the digestate is phytopurified by macrophyte culture, while the solid fraction of the digestate is vermicomposted. The result of this process will be the production of two products: vermicompost (transformation of humus by earthworms) and a mineral fertiliser. Both products comply with the French standard. The main arguments used by LLDC Algae to increase sales are the results obtained by farmers.

## 4. Managerial recommendations

### 4.1 Technical constraints and limits to consider

Even though bio-fertilizer technology is a low-cost and eco-friendly technology, many constraints limit its application and implementation among the users; these constraints are technological, infrastructural, financial, environmental, human resources, unawareness and quality (Udemezue & Mmeremikwu, 2021). Entrepreneurs should invest more in the bio fertilizer industry and provide financial assistance for start-ups (Basu & al. 2021). Chojnacka et al. (2020) concluded that the priority directions and political determinants are important to implement such technologies. Application of potential bio fertilizers that perform well in the laboratory and greenhouse conditions often fails to deliver the expected effects on plant development in field settings (Basu and al., 2021 and Udemezue & Mmeremikwu, 2021). Different studies concluded that there are still much more efforts and collaboration between experts on plant and microbial genetics, molecular biology and ecology that are required so that sustainable microbial-based agro technologies could successfully be attained (Awasthi et al., 2019, Kour et al., 2020).

### 4.2 Economic and industrial factors for adoption and improvement

The following managerial recommendations are provided for the different scenarios for the development of microalgae as an agricultural fertilizer:

#### 4.2.1 Scenario 1: Increase in demand for microalgae-based fertilizers

Recommendations:

- Invest in the expansion of production facilities according to the industrial territory configuration (nature of the existing industrial parks) to meet the increase in demand
- Propose partnerships with existing industries needing wastewater treatment for industrial symbiosis (Kalundborg model: Gulipac, 2016, Sun et al., 2024) development leading to circularity and carbon neutrality
- Optimize production processes to increase yields, profitability and symbiosis
- Develop new microalgae-based products and formulations to diversify the offering
- Strengthen research and development teams to drive continuous innovation targeting bioproduction symbiosis systems, formulation and circularity.
- Set up strategic partnerships with industrial and agricultural players to better understand market needs both in term of bioproduction and end-usage.

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<sup>21</sup> LLDC ALGAE. (2021, 9 décembre). Présentation LLDC Algae [Vidéo]. YouTube. <https://www.youtube.com/watch?v=ZpKfYQTd7VA>

#### 4.2.2 Increased competition from synthetic fertilizers

Recommendations:

- Differentiate by emphasizing the environmental benefits and sustainability of microalgae-based fertilizers
- Invest in marketing and communication campaigns to promote the benefits of microalgae
- Optimize production costs to be more price competitive
- Develop high added-value products, such as fertilizers enriched with specific nutrients
- Forge partnerships with distributors and retailers to extend the commercial reach

#### 4.2.3 Stricter regulations on the use of fertilizers

Recommendations:

- Quickly comply with new regulations by adapting production processes and formulations
- Invest in research and development to create products that meet regulatory requirements
- Work closely with the relevant authorities to anticipate regulatory changes
- Implement enhanced traceability and quality control systems
- Communicate transparently on the company's sustainability and compliance efforts.

To sum up, the key recommendations are to be agile, innovative, customer-focused and sustainable to adapt to the various scenarios in the microalgae-based fertilizer market.

### **5. Presenting recommendations of collective interest**

There is a clear collective and public interest in optimizing agricultural fertilizers using microalgae. This is due to the following reasons:

#### 5.1 Environmental sustainability

Microalgae are a source of natural and renewable fertilizers, with a reduced environmental impact compared with chemical fertilizers. Their use reduces the use of chemical inputs and preserves the quality of soils and ecosystems.

#### 5.2 Food safety

Microalgae-based fertilizers help to improve agricultural yields in a sustainable way, thereby enhancing food security. They enable the feeding of a growing global population while preserving natural resources.

#### 5.3 Public health

- Microalgae offer a healthier and more environmentally friendly alternative to chemical fertilizers, reducing the risk of food and water contamination.
- This has a positive impact on the health of consumers and farming communities.

#### 5.4 Local economic development

The production and use of micro-algae-based fertilizers creates new jobs and economic opportunities, particularly in rural areas.

This contributes to local economic development and the revitalization of farming communities.

## 5.5 Innovation and research

The use of microalgae in agriculture stimulates innovation and research in areas such as biotechnology, green chemistry and sustainable agriculture.

This helps to advance knowledge and develop new solutions to environmental and food challenges.

In short, the collective and public interest in optimizing agricultural fertilizers using microalgae lies in the environmental, social and economic benefits it brings on a local and global scale. It is a promising way of reconciling agricultural productivity with the preservation of natural resources.

## 6. Conclusion, limitations and research approach

The financial capacity to invest, the government support through regulations and politics, and the progress of the research, based on a collaboration between searchers and farmers, the communication of the results to a better-informed public (consumers and farmers) are essential to assist the growth of viable businesses that are producing bio fertilizers for a more sustainable agriculture.

The study was focused on a limited liability company located in the west of France. As a result, the analysis is concentrated on this business model type, that has its strengths and weaknesses. However, it would be interesting to enlarge it and include different company categories from start-ups to big groups to confront the recommendations and check if it applies to all of it.

To conduct a marketing study with questions to farmers would outline their current knowledge about bio fertilizers and determine the obstacles and main motivations for changing their production methods (mainly going from the use of chemical fertilizers to more sustainable fertilizers).

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