CONCLUSIONS AND RECOMMENDATIONS

The microalgae sector in the Mediterranean

Prospects and contribution to sustainable development

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CONCLUSIONS AND RECOMMENDATIONS[1]

The microalgae sector has a **significant potential** in a context of transition from an economy based on fossil resources and globalised mass-market industry towards a "circular and territorialised bioeconomy" meeting the growing demand of the civil society.

Indeed, algae account for half of the global biomass reservoir, and therefore, they represent a real "carbon sink". More specifically, microalgae plankton presents several assets such as diversity and physiological functioning, and can be found in seas, lagoons and fresh waters. Renewable resources and their use via biorefinery processes, developed to encourage sustainability (environmental and social positive externalities), have a bright future ahead, all the more so as they can adapt to climate change.

Microalgae have **many advantages**. The first one is their physiology: photosynthetic growth using solar energy and the atmospheric CO_2 or the CO_2 coming from industrial fumes in a heterotrophic mode, and emitting oxygen; nutrients (inorganic nitrogen and phosphorus) coming from all sorts of waste, of which sewage water. Another asset is the generated metabolites that can be used for multiple health applications, such as: preventing certain diseases, like ARMD or Alzheimer, supplementing deficiencies in micronutrients and proteins. They can also be used in the field of cosmetics (natural components), animal and human nutrition (colouring agents, food thickeners, aromas, unsaturated fatty acids and essential amino acids); plant chemistry (biorefinery concept) and fermentation industries, and even in biofuels (especially for aircrafts, as other vehicles tend to resort to electricity or hydrogen).

Another advantage of microalgae regards their conditions of production compared with other biomass sources. As they multiply quickly, their productivity by surface unit is very high (continuous production over 7 months in northern regions and 10 months in the Mediterranean region, that is 5 to 10 times more than in conventional agricultural production). Their 3D factor is also an asset. Besides, production facilities can be set up on non-agricultural soils, in brackish or alkaline basins or lagoons, thus avoiding conflicts regarding the use of soil and water, and therefore tensions on the food markets, which are quite volatile. Thirdly, as recycling fertilizing inputs is easy, the level of pollution generated by production sites is low and can be controlled easily. Finally, it is much easier to capture and reuse the atmospheric CO_2 (by reusing carbon) than that produced by farming and forests.

The constraints that slow down or weaken the microalgae sector development all over the world are due to (i) the multiplicity of recyclable biomass sources (forests, crop and livestock farming, food-processing industries, urban waste) thus creating asymmetric competition and (ii) to the (extensive/intensive) technological and business (capital and costs) models that are mostly being tested and therefore not controlled yet.

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Microalgae have multiple applications and open up new markets.

In agriculture (fertilisers, pesticides and animal health products/bio-based simulators of plant natural defences and phytohormones to substitute synthetic molecules), the market is growing fast, with the development of organic products all over the world and the global demand to reduce chemical inputs (Zéro Phyto, etc). Besides, the agri-algal artisanal sector combining agricultural and microalgae production complies with sustainable development criteria (cf. infra, recommendation in favour of a territorialised circular bioeconomy).

As regards high-value molecules (health, cosmetics, food), the market seems almost ready to take off due to the pressure of consumers who are keen to consume food supplements with alleged health applications as well as natural products with an organic connotation. The same goes for the recycling of industrial and organic waste, with an almost balanced economic performance subject to regulatory incentives, in spite of significant investments.

As for other applications (proteins for animal food supplements, especially in aquaculture) the market is open, subject to the safety and regulatory aspects as well as the requested volumes. The development of biofuels, however, seems more remote (10 to 30 years). The products covered (food and energy) are subject to mass production and/or currently depressed speculative markets (cereals, oil seeds and pulses, oil) that can hinder their expansion.

This is why several major R&D programmes and many start-ups were created over the last fifteen years in high-income and emerging countries, mostly in Europe, North America and East Asia.

The SWOT analysis shows that in Europe and in France in particular, but also in all the Mediterranean countries, the microalgae sector still presents weaknesses and challenges. Significant efforts must be made in terms of R&D (and therefore of budget dedicated to innovation) and material (production units) and immaterial (training and communication) investments.

The Mediterranean region, and SEMCs in particular, are facing major challenges regarding:

- Social issues (creating 66 million jobs between 2015 and 2030 and 71 million between 2030 and 2050, that is over 5 million per year);
- Food issues (feeding 125 million extra people by 2050) by ensuring quality food in sufficient amounts, in spite of scarcer water resources and climate change;
- Environmental issues (reducing multiple land and marine pollution and ensuring air, water and environment quality).

Given the scarcity of biomass resources, exceptional insolation and significant sea and lagoon surfaces, microalgae could be a great opportunity in this region, however they would only indirectly and partially meet the food safety issue. Indeed, sustainable food safety requires quality self-production, in a sufficient amount (principle of food sovereignty). Yet microalgae do not qualify for abundant food production, as they are not competitive compared with vegetable protein sources such as native legumes and the dominant soy. The same goes for algal biofuels. However, microalgae can be used in situations of serious occasional food deficiencies, to be used as emergency nutritional products. Microalgae are relevant in the Mediterranean basin for all the other applications: depollution, agriculture, ingredients for animal and human nutrition, functional food.

We must imagine an **economic model adapted** to the Mediterranean geographical constraints that present a completely different configuration according to the environment. Coastal megalopolises are developing in an industrial area with dense infrastructures, while rural spaces are often isolated and under-equipped.

In the first case, Western, Japanese, Chinese or local emerging technologies should be suitable and major conventional energy businesses will mobilise them via self-funding and resorting to the financial market. The Cop21 agreements will boost a promising market of depollution and by-products.

In the second case, we must encourage an integrated sustainable rural development. We must invent a new economic model. It will be based on the concept of "**territorialised circular bioeconomy**" and will rely on family agriculture connected with upstream and downstream sectors within a network, via knowledge-sharing sensors and platforms, inputs and logistics channels. Microalgae produced following strong processes can play a significant role in terms of waste management and be a source of high-value food and energy by-products. For instance, microalgae farms - which often take the form of cooperatives - will create their inputs via the methanisation and the composting of animal manure or inedible vegetables. They can get their inputs from the region's farms and as biomass suppliers, they will help create new or complementary activities among local food-processing, cosmetics and chemistry SMBs.

Strategic recommendations

Developing the microalgae sector in Mediterranean countries requires to define national strategies that are coordinated at the regional Euro-Mediterranean level as well as devices adapted to local needs in the knowledge (R&D, training), businesses and public sector chain. Attention must be paid to the structure of the value chain in terms of dimension of actors and repartition of costs and profits (finding a balance in market powers).

Upstream (R&D)

- Objective: *creating a* ***laboratory consortium in Mediterranean countries*** *that could be done at the initiative of the "Pôle Mer Méditerranée" of Toulon, via a rapprochement with its scientific partners in Spain, Greece, Italy, Portugal and in SEMC.*

- Suggested structures: The European Research Network ER-Net ARIMNet (Agricultural Research in the Mediterranean Network), managed in France by the ANR and financed by the EU, could take part in this operation, via the creation of an ER-Net Microalgae Med specific network. Another option is the H2020 « Blue-Growth » group that includes a MED section.

- Actions:

  ◊ Identifying and characterising microalgae species, as well as the processes, technologies and relevant business models for the Mediterranean zone;
  ◊ Conducting scale-ups (pilot projects; demonstration projects) enabling to sort out the species and selecting the most interesting ones at the economic, social and environmental levels;
  ◊ Creating a strain bank (in which there could potentially be GMO strains for industrial applications) or interconnecting existing strain banks;
  ◊ Developing water management techniques in dry and semi-dry climates;
  ◊ Putting together a data bank on patents.

Businesses

- Objective: *launching an observatory and a collaborative platform on microalgal companies in the Mediterranean and* ***creating a cluster of territorialised circular microalgal bioeconomy in a Mediterranean country****, associated to a training centre and a R&D organisations network.*

- Suggested structure: ANIMA

- Actions:

  ◊ Encouraging business creations in collaboration with universities and research organisations (incubators), by favouring the rural sector through the association of multifunctional family farms (animal and vegetable raw materials, development of microalgae-based by-products, especially energy ones, ecosystem and tourism services);
  ◊ Training qualified personnel and popularising/training installation operators in rural zones;
  ◊ Networking and sharing of means;
  ◊ Learning by doing and encouraging potential actors with the pilot and the observatory.

Public sector

- Objective: *developing* ***national strategic plans*** *on "microalgae and territorialised circular bioeconomy".*

- Suggested structure: National Development Agencies

- Actions:

  ◊ Setting objectives for the microalgal sector;
  ◊ Simplifying administrative procedures for business creation and management;
  ◊ Adjusting regulations to enable commercialisation with a right to experimentation and a reduction of certain procedures complying with traceability as well as human, animal and environmental safety;
  ◊ Implementing investment incentives;
  ◊ Implementing tax incentives;
  ◊ Facilitating the installation of industrial pilots enabling market tests;
  ◊ Implementing a national programme of R&D, training as well as technology and economic watch.

Euro-Mediterranean cooperation

- Objective: *Developing a* ***Euro-Mediterranean Strategic Plan*** *dedicated to "microalgae and territorialised circular bioeconomy"*

- Suggested structure: IPEMED and EU (Specific section of the European Neighbourhood Instrument (ENI), INTERREG V and WestMed programmes), with the implementation of co-production sectors (starting with spiruline).

- Actions:

  ◊ Implementing a regional programme of scientific and technical cooperation;
  ◊ Implementing incentives to develop Euro-Mediterranean co-production sectors in compliance with IPEMED's recommendations.

Among the multiple biomass resources that can be mobilised, microalgae are a very promising sector. Nevertheless, on their own they are not a solution to all the issues raised by sustainable development as the stakes are significant, and they are in competition with other biosourcing opportunities, while financial resources are limited. Therefore, the actors of the microalgae sector must get organised to reach a critical size by cooperative strategy in order to convince political and economic decision-makers of the assets of this sector.

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