Focus Area: ECOSYSTEM AND NATURAL RESOURCE MANAGEMENT
Market Segment: ALGACULTURE

SIC Code: 112519, 325411
Segment Score: 23

Sample Investments:

- ***Private:*** Establishment and expansion of Algae and Seaweed farms, some in coordination with aquaculture farms for more sustainable feeds
- ***Private:*** Production of products for food, medicines, biofuels, cosmetics
- ***Public:*** Establishment of Algaculture regional accelerators & research hubs

1. **Relevance to ADB's Ocean Action Plan *(Score: High=3)***
    a. Algae are a class of photosynthetic organisms found in both marine and freshwater habitats - with rapid-growth properties. We consider both microalgae (comprising the majority of cultivated species to products) and macroalgae (or seaweed - a growing food market).
    b. Sustainable food, biofuel and health care production should make the algae industry a top priority. In addition, algae is used for pollution control at sea. Algaculture supports ADB goals with local source, sustainable production of food, pharmaceuticals, fertilisers and transportation fuels.
    c. The market is in relatively early stages, requiring a combination of technology development, industry support, market education and blended finance to realise its full potential in Asia. Marine BioTech is the broad research field, which is a priority in the European Union and some Asian nations.

2. **Positive Environmental Impacts? *(Score: High=3)***
    a. AlgaCulture Farming has virtually none of the environmental hazards of AquaCulture and MariCulture. Because there is neither animal production nor feed, those risks are non-existent. AlgalBlooms, of course, occur in nature often due to anthropomorphic stress but this does not happen on algae farms. In fact, *Chlorella* is a strain of algae used to clean up water pollution by reducing Hg2+ to the less toxic elemental mercury.
    b. Algae-based biofuel is, arguably, more socially-acceptable than land-based feedstock, although water-use in production may be high. However, debate continues about commercial feasibility and environmental impacts of biofuels in general - in spite of considerable market potential. This is largely in a testing phase, wherein ADB and DMCs may play a part.

3. **Positive Social Impacts? *(Score: High=3)***
    a. Poverty: Algaculture offers job creation and positive, vegetable-based nutrition - independent of location. The sector favors SMEs and local production of locally-used products and niche exports.
    b. Gender: This segment has similar workforce and ownership properties to AquaCulture. Because it is so new, little data is available on social or gender

issues. But we score AlgaCulture higher because: 1) there are fewer references to cultural barriers against women, as it is a new field, 2) profitable, niche products are more abundant, giving opportunity to women entrepreneurs, 3) mariculture heavily favors men due to higher risk levels at sea and boat maintenance, which are not issues in AlgaCulture.

c. Covid19: Over 1000 marine compounds have demonstrated antiviral activity. Some, like griffithsin (derived from red macro algae), have already demonstrated activity against other coronaviruses. Aquatic enzymes are also a fundamental component of PCR, which is used widely in covid-19 testing.

4. **Potential for Market Scalability? *(Score: Medium=2)***
   a. While long-term potential for scalability is high, key factors must be resolved in the short-term: Production capacity, product testing, regulatory approvals, development of specialised labor and the opening market channels.
   b. *Consumer Markets:* According to a 2018 report by ReportLinker on the global algae market, the algae products market was around $4.0 billion in 2018 and will grow to $5.2 billion by 2023 (CAGR 5.4%). The report also notes that during this same time period, 2018 to 2023, algae protein and the nutritional and dietary supplement segment (eg, blue-green algae) is projected to have the highest growth rate - with Asia-Pacific leading global growth overall.
   c. *BioFuels Market:* High growth (CAGR of 8.8%) is also forecast for algae-based biofuels, reaching $10.7bn in 2025. However, technological challenges and high capital investment in algae biomass and fuel production are expected to limit the industry growth.
   d. Antiviral Products are likely to grow at an accelerated rate, as marine compounds are tested and produced at scale.

5. **Capacity for Innovation & Growth? *(Score: High=3)***
   a. Algaculture growth depends on innovation, and both are potentially very high as noted above.
   b. Food Innovation: Government approvals of MicroAlgae, on a global basis, lag innovation (only 3 strands are approved for food products in Europe). MacroAlgae (Seagreens) are widely accepted in Asian diets and need only to achieve more economical production and distribution methods. Both micro- and macro-algae meet the high demand for sustainable protein.
   c. Health Care Innovation: Approvals need to be expedited for health care applications as well. Covid-19 applications from marine algae may accelerate attention and approvals for the segment. From nutritional supplements to pharmaceuticals, a range of algae-based products are already on the market.
   d. BioFuel Innovation: Transportation is expected to dominate the algae biofuel market, accounting over 70% of the overall demand by 2025. High potential to replace diesel and gasoline in cars and, to a lesser extent, in ships. Asia Pacific, thanks to rapid technological advancements and low raw material costs, is expected to lead global growth in algae biofuels with 8% CAGR to reach $2bn revenues by 2025. Innovation must be coupled with regulatory support and market development if this forecast is to be fully realised.

6. **Benefit from Regional Governance? *(Score: High=3)***

a. We also give this criteria a high score because Algaculture, whilst ticking all the boxes of ADB and SDG criteria, depends on basic research, technological cooperation, scale production and regulatory support. All parts of the value chain could be improved by the support of regional policy and science frameworks.
b. DMCs should be encouraged to collaborate on a regional basis during the next 5-10 years as this segment moves from early-stage to one of the highest growth, widely used products of the blue and green economy. Europe's JPI Oceans, for example, effectively coordinates and supports the research efforts of some 30 nations to advance algae and marine biotech applications. Yet many algae industry players complain of the slow EU approval process for food and health applications. Asia could learn from this experience.

7. **Opportunity for SMEs?** ***(Score: High=3)***
    a. Opportunities are abundant for niche winners in the many segments of AlgaCulture. Market fragmentation, as with AquaCulture, will eventually lead to consolidation. But we are probably 5+years away from that stage.
    b. Major players in the food/health sub-segment, who sponsor niche products and seek acquisitions, include: Cargill (US), DowDuPont (US), DSM (Netherland), BASF (Germany), Cyanotech (US), Kerry (Ireland), Ingredion (US), CP Kelco (US), Corbion (Netherland), Roquette Frères (France), Fenchem Biotek (China), E.I.D Parry (India)
    c. Major players in the algae biofuels sub-segment include: Algenol, Blue Marble Production, Solazyme Inc., Sapphire Energy, Culture Biosystems, Origin Oils Inc., Proviron, Genifuels, Algae Systems, Solix Biofuels, Algae Production Systems and Reliance Life Sciences.

8. **Attract Private Investors?** ***(Score: High=3)***
    a. Private investors with a mandate for sustainability will find AlgaCulture attractive. Many opportunities are in early-stage, so some risk mitigation will be required to attract institutional investors. This may take the form of blended capital to industry sponsors to portfolio diversification.
    b. Because of the multi-industry applications and scale necessary to dominate any sub-segment, AlgaCulture investment will probably be dominated by industry insiders in its current growth stage. However, we agree there is a role for ADB and regional frameworks/accelerators to sponsor the build-out of this important segment. Such activity will also attract private investors.

REFERENCES: ALGACULTURE

In addition to Aquaculture references, see:

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See-how-algae-could-change-our-world, Forbes, April 2018
Algaculture. Wilkepedia
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European Algae BioMass Association
Algae-Products-Market-by-Type-Application-Source-Form-And-Region-Global-Forecast. Reportlinker.com
Emergent Ocean - Marine BioTech Research