GAIN
Green Aquaculture Intensification

newsletter

Number 5 December 2021

GAIN key findings and recommendations

for improved policies that support eco-efficient aquaculture

The current status of aquaculture in Europe

The EU aquaculture sector has a large potential to grow and meet the increasing demand for more sustainable seafood. According to the EUMOFA 2020 report, the self-sufficiency rate for fisheries and aquaculture products was about 42%. Aquaculture products, including imports, represent 25% of EU seafood consumption: of these, less than half came from EU aquaculture.

Aquaculture is strictly regulated in the EU and EAA, guaranteeing that farmed products Made-in-Europe comply with high food safety and quality standards. This comes to a price, i.e. EU products are often less competitive, pricewise, compared with those imported from other economic areas.

Consumer demand for sustainable, healthy locally produced, seafood is increasing: aquaculture has the potential to meet this demand by increasing production volumes while ensuring adequate quality standards and sustainability. Moreover, consumer demand for ready-made meals is on the rise. This also stimulates the creation of new value chains, based on the reuse of by-products, i.e. shells, fish heads, trimmings, bones and viscera, which, at present, are under-utilized.

Modern intensive aquaculture is a relatively new industry, which is little-known to most consumers. In this situation, misleading information about welfare of farmed fish and the impact of aquafarming on the environment has already led to high profile criticism of the sector, reduced social acceptability of aquaculture products and difficulties in implementing science-based spatial plans for new aquaculture areas.

In order to meet EU consumer demands, it is necessary to increase both production volumes and values, without increasing (and, if possible, decreasing) the environmental footprint of aquaculture. These multiple goals can be achieved by ecological intensification (or eco-intensification) of aquaculture.

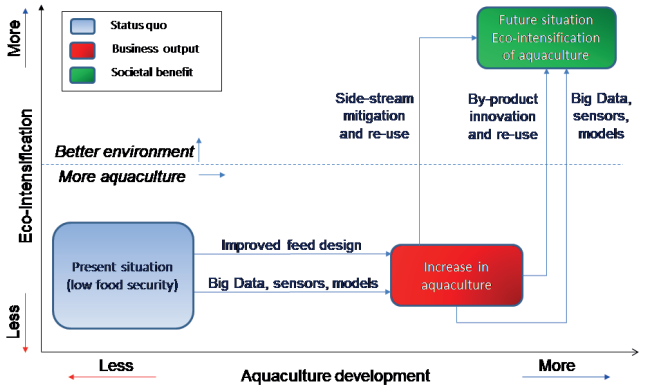

Figure 1: Schematic representation of the GAIN vision of ecological intensification.

GAIN project in a nutshell

GAIN, Green Aquaculture INtensification in Europe, was designed to support the ecological intensification of aquaculture in the European Union and European Economic Area. The project, funded by the Horizon 2020 EU research programme, aimed at increasing production volumes, the profitability and the competitiveness of this sector, while ensuring sustainability, fish welfare and compliance with EU regulation on food safety and environment.

Results obtained by project GAIN indicate that it is possible to achieve better economic and environmental performances in aquaculture.

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Towards the ecological intensification of aquaculture: main trends

Aquaculture digitalization: implementation of precision aquaculture

Digitalization is one of the key approaches to meet the emerging consumer demands for more sustainable and higher quality 'blue food'. Such a move towards precision aquaculture, will contribute to the European Green Deal. It will improve husbandry practices and facilitate data interoperability, enhancing transparency across supply chains. It will also reduce market stickiness, with relevant information being delivered to consumers.

GAIN has developed tools for the implementation of Precision Fish and Shellfish Farming. Worldwide, aquaculture is a very diverse sector and even in the EU there are large differences in the technological maturity of different farms. For this reason, GAIN developed an advanced prototype of a **scalable and flexible Information Management System (IMS)**, represented in Fig. 2. The GAIN IMS combines a centralized cloud computing platform, including AI models, with peripheral nodes, addressing the requirements of open-water and land-based farms, those of large companies as well as those of small farms.

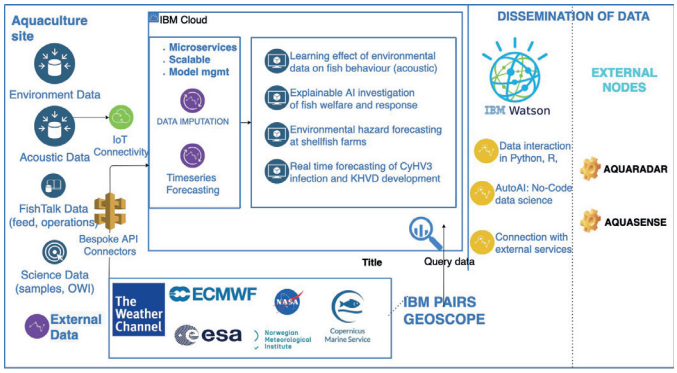

Figure 2: Overview of the system presenting IoT data integration, connectors to external data, microservices and automated model training and scheduling, and user interaction with the system.

The IMS was deployed at salmon farms in Norway, seabass and seabream in Spain, rainbow trout in Italy, mussel farming in Portugal and Northern Ireland (UK), oyster farming in Northern Ireland (UK). GAIN partner Dalhousie University applied a similar concept to salmon farming in Canada. In these case studies, a range of innovative tools were tested, namely:

- Dynamic models for smart management of oxygen supply, based on data assimilation algorithms;
- Dynamic models integrating financial analysis for predicting fish/shellfish growth, local environmental load and financial returns;
- Data driven models for short term predictions of environmental variables.

Aquaculture digitalization: connecting stakeholders of aquaculture supply chains

Interaction between buyers and sellers is a confidential commercial operation, and in supply chains (supply webs) the upstream and downstream links of the chain nodes (i.e. intermediaries) are known only to themselves. Adjacent nodes are deliberately excluded from this information, in order to avoid the potential elimination of the intermediary or 'middle-man': this generates long supply chains that dilute value and increase product cost. Platforms for vertical integration of data along aquaculture supply chains are emerging, e.g. https://www.cobalia.com/welcome.
In order to reduce market 'stickiness', which results in long supply chains and costly goods, GAIN relied on making public in a way that is easy to use, both the origin of different aquaculture products, and the pricing of aquafarming products. The SailFish web application (https://longline.co.uk/meta), represents the first attempt in connecting the opposite ends of the market.

Sustainable aquafeeds

Ensuring sustainable feed systems is a main issue for aquaculture to join the green transition. The aquafeed industry has already made very significant progress towards this, through the use of plant-based ingredients, and is striving to progress further by finding more alternatives to further replace less sustainable ingredients. GAIN designed and tested a **range of novel feeds**, which included emerging ingredients, i.e. insects, seaweeds, microalgae, land-animal Processed Animal Proteins, fish meal and oil from fisheries by-products, microbial biomasses, algal oils, and Fish Protein Hydrolysates from aquaculture by-products. These feeds were trialed on Atlantic salmon, rainbow trout, European seabass, gilthead seabream and turbot. The comprehensive GAIN data sets show that new formulations do not affect fish welfare and guarantee good zootechnical performances, and confirmed that it is possible to produce fish using formulation concepts and ingredient baskets that fit into a circular economy framework.

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The results of economic analysis and LCA indicate that these GAIN feed formulations could become profitable and environmentally more sustainable if: i) the cost of emerging ingredients would decrease, due to increase in demand and production volumes; ii) renewable energies would be used in rendering process. Given the high interest of feeding companies in emerging ingredients and the strong commitment of the EU in implementing the energy transition, it is reasonable to expect that these two conditions will be met in the present decade.

Enhancing aquaculture circularity

Increasing aquaculture circularity was the second main pillar of the GAIN vision of ecological intensification. GAIN developed processes leading to the reuse of aquafarming wastes and by-products not only within the aquaculture sectors but also elsewhere in the food or industrial sectors. GAIN also explored co-farming of different species, by implementing integrated systems, in which effluent from one compartment of the system can be used as influent from another one.
GAIN EU/EAA partners developed innovative processes for **reusing and valorizing**:
• **side-streams**; Two processes for drying and sanitizing fish sludge from RAS and a process for drying and sanitizing mortalities are ready for commercialization. The end product of these processes, may be reused as fertilizer, biofuel, or insect meal.
• **by-products** from fish and shellfish processing. The reuse of mussel shells from the canning industry as filler media in RAS biofilter was developed, and shells seem to be a good candidate for substituting plastic filler media. Moreovover, processes for extracting valuable secondary products, namely FPH, peptones, collagen, gelatine, from farmed fish were optimized at pilot scale.
However, the full exploitation of GAIN innovations, may require changes in the current EU legislation.

Meeting the demand for traceable and sustainable products

Improving communication towards consumers is essential to increase the understanding of ecological intensification, as the cost of more sustainable products, farmed in the EU/EAA in compliance with high food safety and environmental standard regulations, could be compensated by a premium market price.

GAIN pioneered efforts so eco-intensified products can be competitive by:

i) developing and testing a comprehensive composite indicator for benchmarking eco-intensified products - the **EISI Eco-Intensification Sustainability Index**; the EISI was applied to the salmon supply chain in Norway: the results are summarized in Fig. 3: Overall, the salmon industry performs well, despite extremes with around 10% to 25% of the industry rated as poor for welfare, environmental or social standards.

Figure 3: EISI indicator results for Norwegian salmon production.

ii) communicating this information to consumers in a simple and appealing way by prototyping a web-based application - **GoodFish**, and allowing them to provide feedback on their culinary experience. Figure 4 shows an example of this functionality, and detailed information on each product can be reached by a QR code.

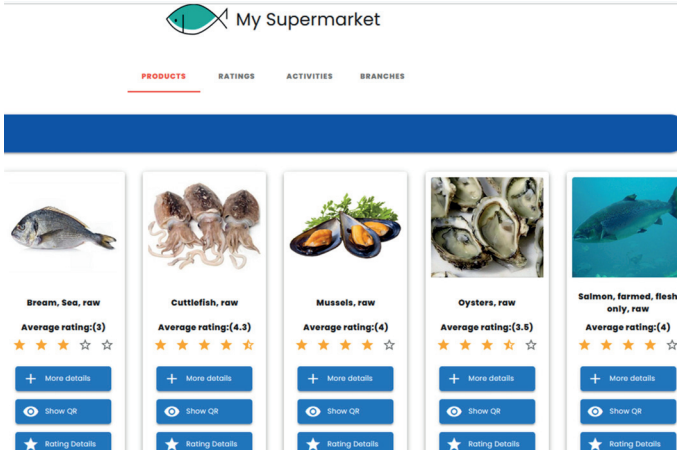

Figure 4: View of business intelligence platform (cloud backend) of the GoodFish app.

Fostering low environmental footprint aquaculture

Proteins from seafood are generally accepted to have a lower environmental footprint, compared with terrestrial ones. Moreover, shellfish and seaweed farming, can also provide relevant regulatory ecosystem services, contributing to mitigate climate changes and to preserve biodiversity. Fostering shellfish and seaweed farming is recognized as a priority in the strategic vision of the EU by 2030.

GAIN looked in detail at the valuation of **shellfish farming bioextraction of nitrogen and phosphorus**, as an additional tool for contrasting the eutrophication of coastal water bodies. This key regulatory ecosystem service has not been used in Europe as part of a management framework. GAIN lower estimates show that, considering only **nitrogen removal by shellfish, the average overall value totals almost 18 billion €**.

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Policies for fostering the ecological intensification of aquaculture.

The EU launched the European Green Deal (EC, 2019), the roadmap for making EU's economy environmentally sustainable, as well as a new Circular Economy Action Plan (EC, 2020). This opens a new horizon for the implementation of circular economy in aquaculture.

According to the European Green Deal, the **green and digital transformation are twin challenges**. In many aquaculture typologies, the digital transformation in its infancy: setting it as a priority in the national strategic plans for the development of aquaculture is a prerequisite for unleashing the potential of Precision Aquaculture. Technology transfer of the most advanced and best management practices could be fostered by recommending to Member States the allocation of EMFAF to digitalization and innovations in supply/value chains, aimed at enhancing circularity.

The **current regulatory framework in aquaculture is complex and sets barriers to the adoption of circular economy processes**. The lack of measures to regulate or incentivise the reinjection of side-streams into productive schemes may pose a burden for the development of circular processes, with the exception of the valorisation of animal by-products (ABP), which is well developed and ruled by Regulation (EC) No 1069/2009. According to the exhaustive analysis carried in GAIN, there is scope for removing some obstacles without affecting food safety, such as:

- **Revise the ban of the use of meal from the same species** in fish feed, as it may affect the efficient valorisation of aquaculture ABPs, and based on scientific evidence on food and feed safety.
- The **restrictions on feed substrates to farm insects** limit its price and nutritional value. Use of food waste (e.g., unsold vegetables in retailers) and by-products of fisheries and aquaculture, could reduced insect meal price, and improve PUFAs nutritional value of insect oils.
- The current Regulation on APB could be revised, to allow the use of certain types of Category 2 fish by-products as fish feed ingredients, provided their safety (e.g. microbiological) is demonstrated by scientific evidence.

- **Aquaculture side-streams** are not efficiently valorised as yet, due to gaps in legislation. The New Regulation EU 2019/1009 is expected to increase the interest in aquaculture sludges as fertilizer.
- **Integrated farming systems: IMTA**. Regulation (EC) No. 767/2009 prohibits the use of animal waste to feed any other animal. This prohibition could **invalidate IMTA schemes including bivalves, sea urchins or other groups**. Morever, complexity of licensing regulations at the national level also limit implementation of commercial scale IMTA in the EU.
- **Seaweeds** bioextract dissolved minerals and trace elements from the surrounding waters and, therefore, could present high concentrations of these potentially harmful chemicals. EU Regulations on the content of contaminants in seaweeds needs to be revised based on scientific studies.
- **Integrated farming systems: Aquaponics**. At present, there is no clear legal status and regulation in the EU. Even though research and technological innovations are quite advanced, this situation is an obstacle to large private investments.
- **Nutrient trading policies**. Eutrophication due to anthropogenic nutrient enrichment of marine and estuarine waters is a major issue in European seas. The bioextraction capacity of bivalve shellfish is a key regulatory ecosystem service that contributes to eutrophication control. Nutrient management at the catchment scale is in line with other policy instruments such as the WFD. **Top-down control of eutrophication via shellfish aquaculture is recognised in qualitative terms but there has been no associated policy development at a European or national level.**

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