Food Systems Dynamics

Research Findings Brief

July 2021

H2020 VALUMICS Project

Norwegian salmon value chain: Flow of products and decision mechanisms

Aquaculture as a solution to increasing demand for food?

Seafood as an alternative for meat

Diet change has been recommended to reduce the environmental impact of meat production and consumption

Norway's salmon aquaculture is a rapidly growing sector with an important role to play in the transition to more sustainable food systems. There is limited land available for production of food, so aquaculture plays an important role in meeting the increasing demand for food. The Norwegian salmon supply chain represents a global food system with a complex logistics network taking feed inputs from one part of the world and distributing products to different parts of the world after processing them in various locations. Only a few countries such as Norway, Chile, Canada and the United Kingdom account for 94% of the global salmon production (2.69 million MT in 2020), with Norway accounting for about 55%. Shift in dietary patterns to more plant-based foods and seafood is recommended to reduce the environmental impact of meat production and consumption. Consumption in Europe will continue to increase as salmon is increasingly being a popular seafood as part of the centre plate.

VALUMICS project is applying a suite of tools to understand the drivers and outcomes of behaviours within food value networks focussing on improving resilience, integrity and sustainability of food value chains. Salmon case study in the VALUMICS project represents the Norwegian farmed salmon chain with production and primary processing in Norway, export to and secondary processing in Europe (mainly in Poland and France) and final distribution to Europe. Research teams from SINTEF Ocean, Norway and University of Iceland have mapped the product flows, decision making mechanisms and factors influencing these decisions in the salmon value chain. Their key findings that formed the input to the development of functional specifications for the VALUMICS simulation model are presented in this brief.

Seafood supply to EU

Atlantic salmon is an important source of seafood in the EU market

Global flows of Norwegian salmon

The flow of products in Norwegian salmon value chain was analysed using the data from Statistical Bureau of Norway (SSB), The Fisheries Directorate, Norwegian Seafood Council, and data from open company reports and scientific literature.

Production cycle of farmed salmon

Feed production for salmon aquaculture

Feed is the most important input for the salmon industry and dominates the overall environmental impact of salmon aquaculture. Norwegian salmon industry sources feed ingredients from crops and marine systems worldwide. Aquaculture feed currently consists of about 30% marine and 70% terrestrial ingredients. The main components of feed are plant and marine fats, marine and plant protein, starch and some micronutrients. Our analysis found that Norway imports about 64% of the fish meal and 78% of the fish oil of its total requirement. Domestic production of fish oil and fish meal is from by-products from fisheries and aquaculture slaughterhouses, where the trimmings and by-catch are used. The terrestrial ingredients comprise of about 70% of the total feed of which soy protein is about 37% of the feed. Approximately 19% plant oils like rapeseed and palm oil are used while starch from wheat and peas used as binders for the feed and account to approximately 11%. Micro additives are also added at 3.7% that include pigments, amino acids and palatability ingredients to compensate for insufficiencies or used as enrichment in the feed. These can be terrestrial, aquatic (krill) or synthetic ingredients. Norway produces 97% of its own feed domestically and 94% of the feed is used for salmon aquaculture.

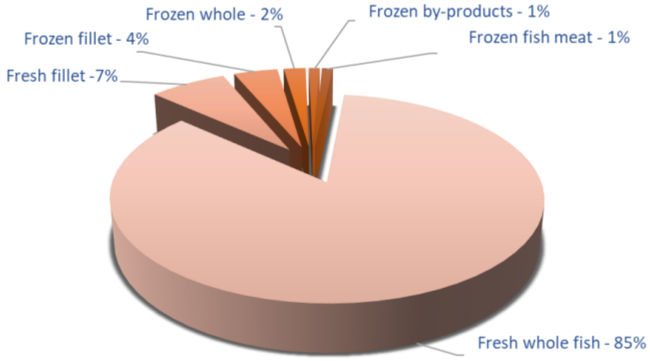
Post-harvest flows of salmon

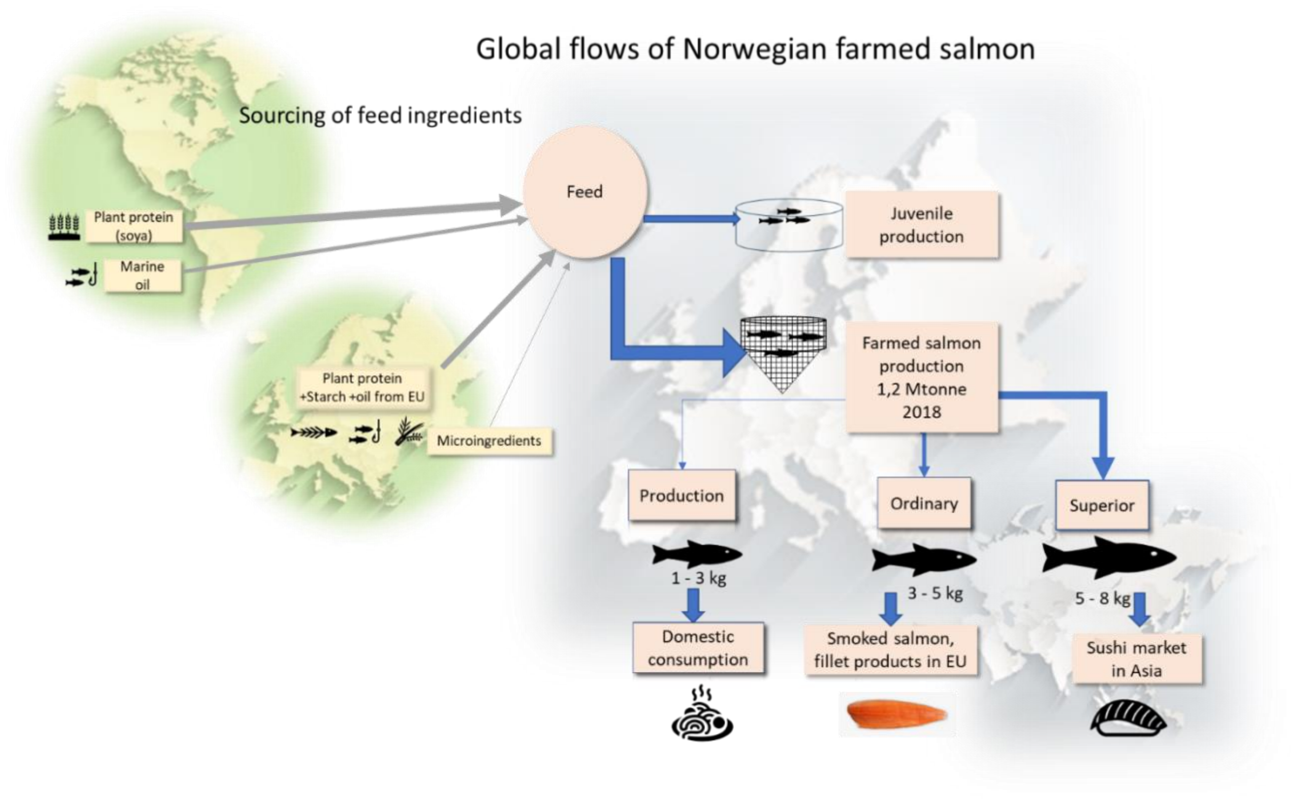
Norwegian fresh salmon exports

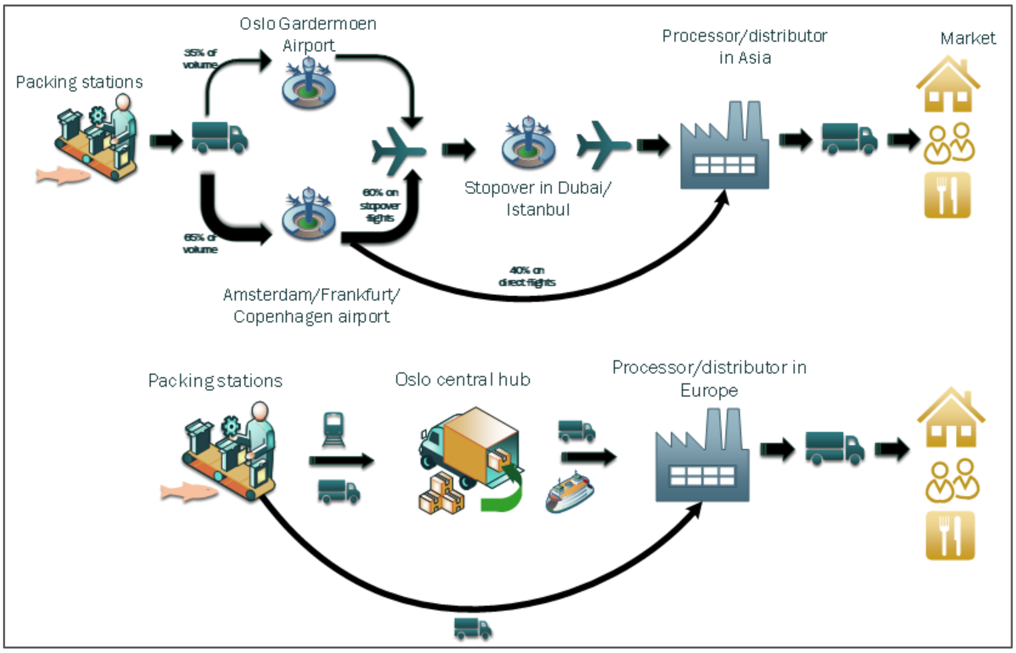
Majority (85%) of the Norwegian salmon is exported as fresh whole gutted fish.

Poland, France and Denmark are the main importers as well as hub-markets that re-export salmon after further processing

After harvesting, salmon undergoes primary processing consisting of slaughtering, gutting and grading by size and quality into three categories: Superior, Ordinary and Production. A major proportion of fish produced in Norway is of Superior and Ordinary quality which is exported. Most of the superior quality is exported as whole head-on-gutted (HOG) fish while production quality fish is only for domestic consumption due to regulatory reasons. Our analysis shows that of all exports, 85% of the salmon exported was in the form of fresh/chilled HOG fish. The three biggest importers of fresh/chilled whole salmon in 2018 were Poland (16%), France (11%) and Denmark (10%) which are also the major hub markets that re-export salmon after further processing. It is at the hub markets that the secondary processing such as filleting and smoking outside Norway takes place. A small fraction of salmon is also exported frozen whole. The following figures show the global flows of Norwegian salmon and the representative logistics chains with transportation modes for export of salmon from Norway to Continental Europe and from Norway to Asia.





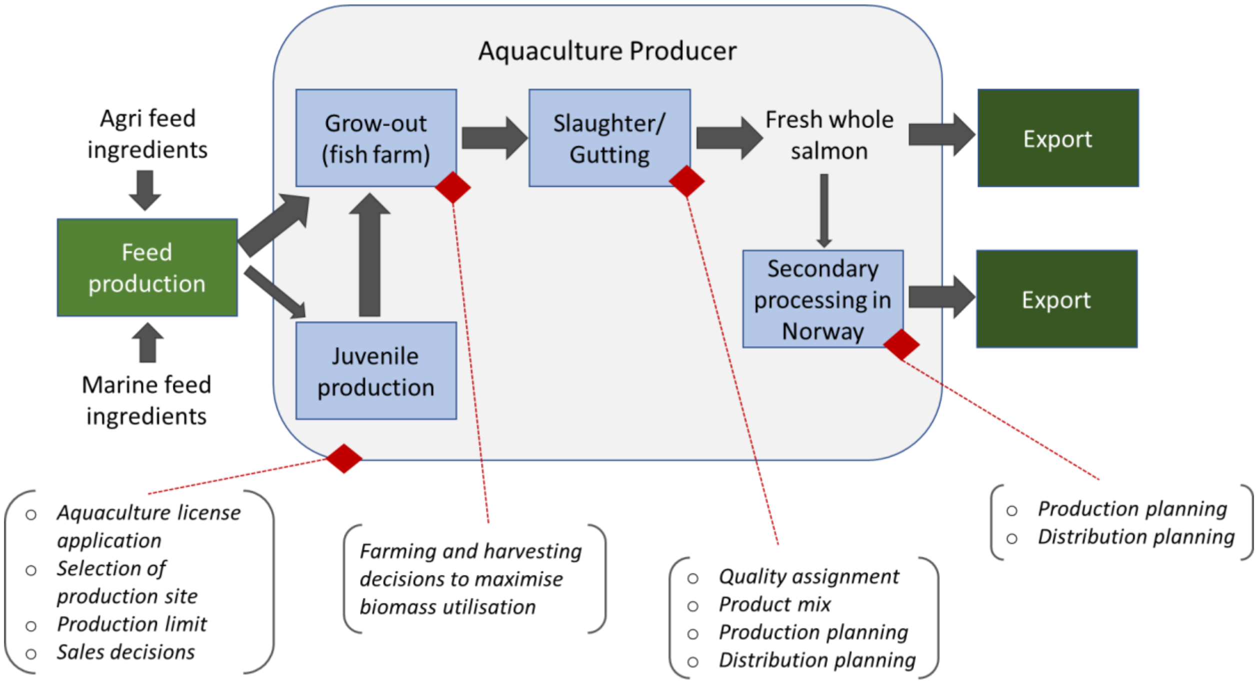


Decision mechanisms in the salmon value chain

Production planning

Production and harvest planning focusses on maximising biomass utilisation while fulfilling sales contracts

Effective decision mechanisms at various points in the salmon value chain are crucial for optimal production efficiency including harvest planning, production and inventory levels, spot market exposure and sales allocation strategies. Salmon aquaculture is also heavily influenced by political decisions in terms of regulation for location of farm sites and processing plants as well as legislation regarding feed use. Therefore, information sharing and timely availability of high-quality data through vertical coordination in the value chain is essential for reducing uncertainties and improving decision processes. The following figure shows the overview of the salmon value chain including material flows and key decisions taken at different stages of the value chain. Understanding of decision mechanisms in the salmon value chain draws from the work performed in the project including expert interviews, current literature and industry reports and formed an input to the development of functional specifications for the simulation model (see D5.2 for details).



Information sharing

Information sharing through strategic collaborations and vertical coordination is crucial for optimal decision making in the salmon value chain

Production plans maximise biomass utilisation

Once a year the aquaculture producers make decisions about increasing their production because they always want to utilise the maximum allowable biomass (MAB) which is the maximum volume of fish a company can hold at sea at all times. In general, one license is currently set a MAB of 780 tonnes in Norway (945 tonnes in the counties of Troms and Finnmark). In addition, each production site has a MAB between 2340 and 4680 tonnes. The producer will, therefore, check if their current biomass is less than the MAB so there is room to add to production. At the same time, they will change their harvesting schedule including the biomass they just added to the harvesting schedule two years (104 weeks) from the current date.

The optimal harvest weight is between 4 – 5 Kg. However, fish are commonly marketed in the range between 3.5 and 7 kg. Volatile salmon prices make the timing of harvest an important factor for profitability. The aquaculture producer has to decide whether to harvest the fish at a known price or to continue to feed until a later harvest and market a larger fish at an unknown future price. However, delaying harvest comes at a price. The farmer has to pay to keep the fish in the pen, a cost consisting both of extra feed expenses. Slaughter (primary processing) capacity plays a big role in the harvesting plan. The processing plant is always running so it's not a question of whether to harvest or not. It's always the time to harvest - the question is: where is the biomass available to be harvested? In other words, which cage (at which site) should be harvested on a given day?

Trading and Export

Salmon production in Norway is export oriented and the value chain is driven by high demand of salmon products

Various factors influence the decision making of actors in the trade of salmon products

Factors influencing decision making in trading

In VALUMICS, factors influencing decision making were mapped to identify suitable indicators to be applicable for simulation modelling with the aim to assess the impact of strategic and operational policies towards fairer food value chains. Following are the key factors, influencing decision making in the context of procedural fairness and the outcome in terms of distributive fairness as it relates to the salmon value chain.

- *Strategic coordination* characterises the governance of the Norwegian salmon value chain. The coordination includes controls of biomass production, collaboration, information sharing and relationship quality which is facilitated by both horisontal and vertical intergration.
- *External factors* influencing decision making are caused by uncertainties in supply and demand because of long production cycles, biological challenges, short shelf life of fresh commodity, price, logistics etc.
- *Power relations* between firms influence decision making capacity and leverage. The salmon producers, in particular large companies have a strong bargaining power against the supermarkets.
- *External constraints* in decision making include regulations on production (licences) and trade barriers, market dynamics, market price and access to market. While demand has been high for a long period, the trade has been favourable for producers. However, the producers are probably price takers in the short term and volatile prices influence profits. Market price is established through supply and demand and salmon is typically traded through free market exchanges. The spot market price is based on information from several links in the value chain, including farmers, exporters and importers. Risk due to volatile prices has been mitigated through flexible contracts between e.g. large integrated companies of producers and supermarket chains or the large value-added processors in Europe.
- *Internal constraints* like financial position, technology, know-how and efficiency are all factors which have impact on decisions of actors in the salmon value chain.

The above factors are all related to procedural fairness. Outcomes are the results of the operational efforts and are realised as distributive fairness e.g. in financial terms (profit) or efficiency, as well as operational outcome reflected in quality, safety, and sustainability[1].

[1] Gudbrandsdottir et al.(2021)

Concluding remarks

Understanding of product flows, trade structures and decision mechanisms is required for modelling of food value chains and to evaluate the impact of operational and strategic decisions policies on value chain sustainability, resilience and fairness. In the years to come, salmon is expected to be more commonly produced on land and in open sea. Production planning and decision mechanisms in the salmon value chain with these new production technologies are expected to have many similarities with today's practice. However, new mechanisms may come into play, e.g., localisation decisions in relation to consumer markets for land-based production, and more complex logistics planning in offshore aquaculture. Besides this, producers are focusing more on value added products, branding, and differentiating themselves in the market to remain competitive.

Key sources for further information

To discuss the research presented in this brief, please email maitri.thakur@sintef.no

Deliverable report citations:

Thakur, M., Johansen, U., Jafarzadeh, S., Čechura, L., Rumankova, L., Kroupova, Z. Z., Jaghdani, T.J., Loveluck, W., Mehta, S., Aditjandra, P., Gresham, J., Esposito, G., Samoggia, A., Ólafsdóttir, G., Gudbrandsdottir, I., Schan, C. S., Sjøberg, I., Richardsen, R., Haug, K. (2020). **Report on Information and Material Flow Analysis for the selected case studies.** The VALUMICS project funded by EU Horizon 2020 G.A. No 727243. Deliverable: D4.3, SINTEF Ocean, Trondheim, 70 pages. DOI 10.5281/zenodo.5105848 *Contact: maitri.thakur@sintef.no*

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Published scientific paper and articles:

Gudbrandsdottir I.Y., Olafsdottir G., Oddsson G.V, Stefansson H., Bogason S.G. **Operationalization of Interorganizational. Fairness in Food Systems: From a Social Construct to Quantitative Indicators.** Agriculture. 2021; 11(1):36. https://doi.org/10.3390/agriculture11010036

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H2020 VALUMICS – Understanding Food Value Chains and Network Dynamics

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