IMTAlking About Sustainability, Baby: Supporting the Transition of Traditional Aquaculture Farmers to Integrated Multi-Trophic Aquaculture

London School of Economics and Political Science

PB403: Psychology of Economic Life Summative Coursework

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Background

"*Everyone has this romantic view of fish farming as a sunburnt old man sitting on a wooden deck beside his dog out at sea. But we really need to focus on being responsible and ethical farmers to ensure sustainability in the food supply chain.*"

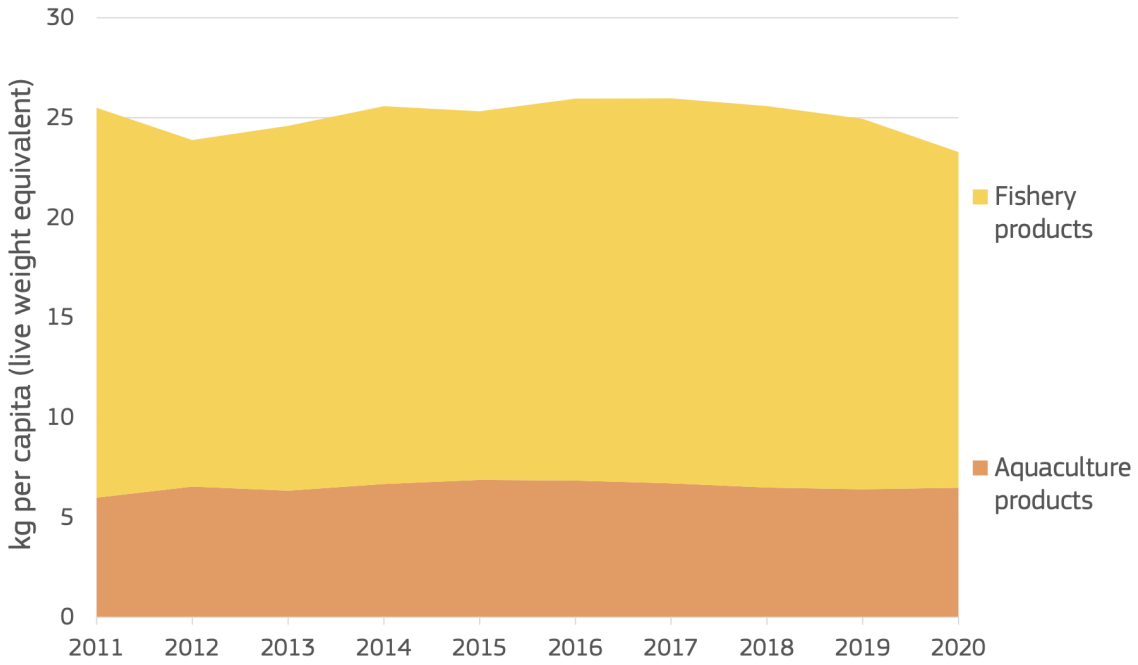
Shannon Lim - founder of Onhand Agrarian farm
(Temasek, 2018)

Over the years, consistently high demand for seafood (see Figure 1) has led to overfishing, which occurs when too many fish in a particular stock are caught while there are not enough remaining fish to breed and sustain a healthy population (MSC, 2024).

Overfishing caused by wildfishing results in massive species extinction, ecosystem destruction, intensified hurricanes, and accelerated melting of Earth's major ice sheets (Dulvy et al., 2021; Issifu et al., 2022). It is correlated with destructive fishing practices like bottom trawling, which uses a tow net dragged along the ocean floor to herd and capture the target species but also destroys the entirety of ocean floors (Issifu et al., 2022). Mainstream commercial fishing corresponds to large amounts of 'bycatch': the caught animals, which can range from small fish to dolphins and whales, that fishermen aren't allowed or don't want to keep. These animals are usually mauled by fishing gear and then discarded (Issifu et al., 2022).

Figure 1

Per CAPITA apparent consumption of Consumption of Fishery and Aquaculture Products in the EU

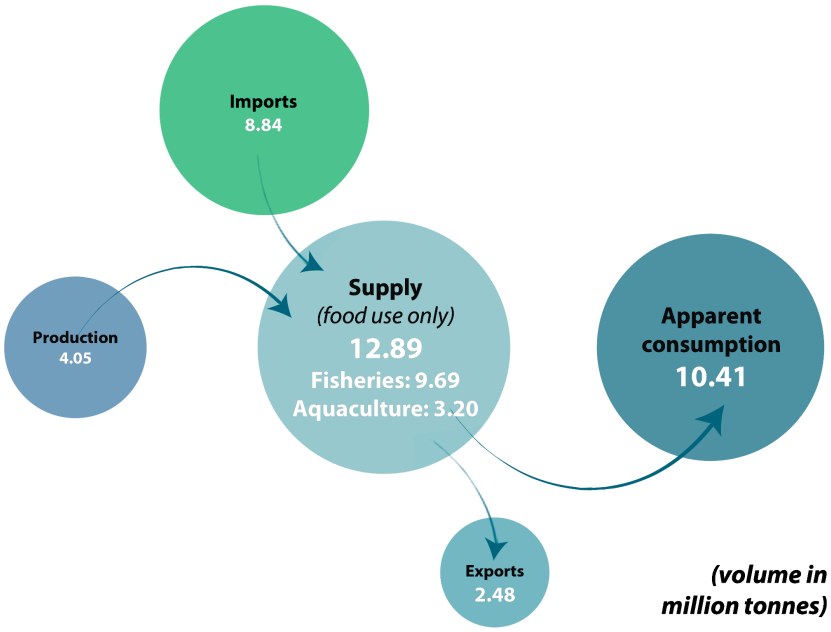


Source: EUMOFA (2020)

Historically, aquaculture, which involves breeding, raising, and harvesting fish, shellfish, and aquatic plants in the water, has been presented as a sustainable alternative to commercial fishing (Nash, 2010) (see Appendix A). To enhance food security and reduce dependence on seafood production from outside European areas, there has been a push towards transitioning away from wild fishing (European Commission, 2021). However, in 2020, imported products still accounted for 8.84 million tonnes and constituted over 60% of the EU's seafood supply, as illustrated in Figure 2.

Figure 2

EU fishery and aquaculture products supply and consumption



Source: ECA, based on EUMOFA (2020).

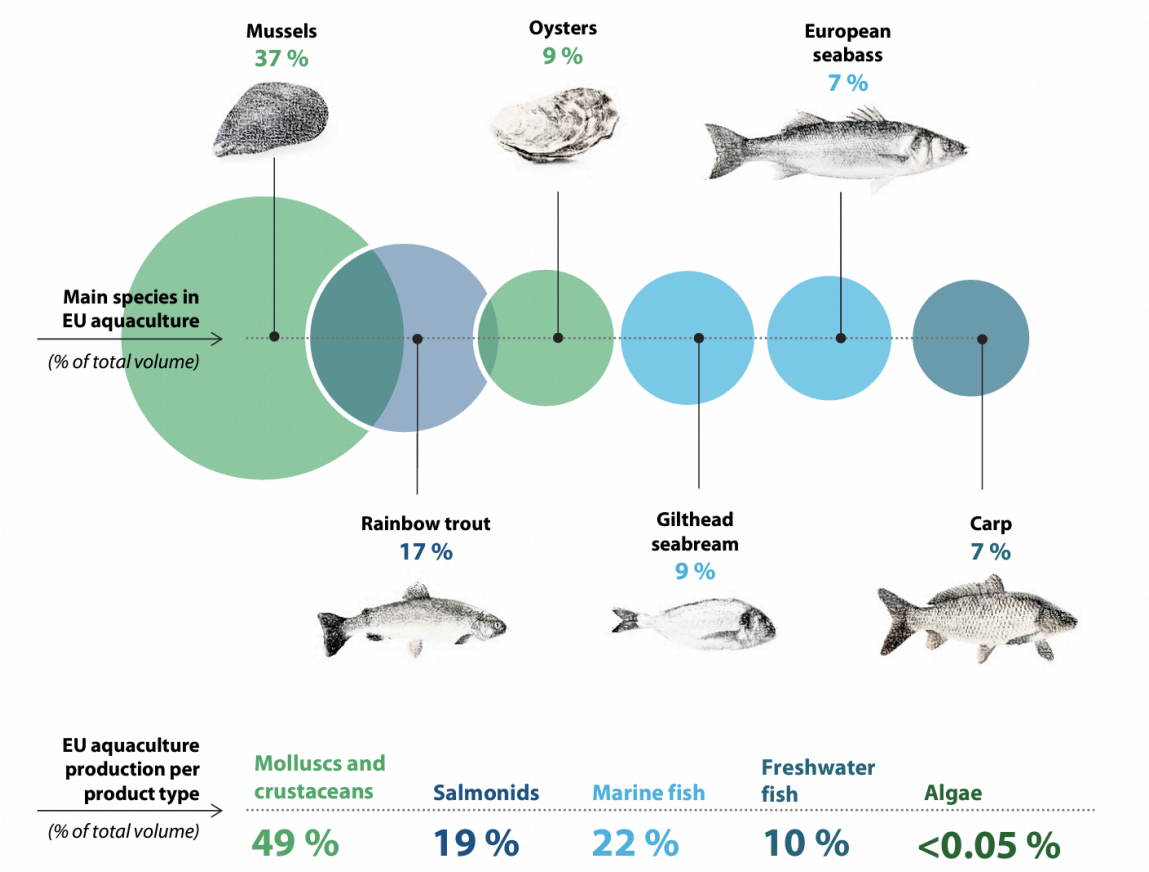
While Europe is lagging behind, the global aquaculture industry is booming. "In 2020, the EU's total aquaculture production amounted to 1.1 million tonnes, accounting for less than 1% of the global total (123 million tonnes) and was worth €3.6 billion" (European Court of Auditors, 2023, 6p.). European aquaculture production is also highly concentrated in terms of the species farmed (see Figure 3).

Although this type of aquaculture lacks some of the problems associated with mainstream fishing, it has its own set of drawbacks: the metal structures and pharmaceuticals used in these farms have detrimental effects on the marine ecosystems, and the restricted movement of the fish and faeces contamination adversely affect both

the health of the fish and those who consume them (Emenike et al., 2021; He et al., 2016; Conte, 2004).

Figure 3

Main aquaculture species farmed in the EU (2020)



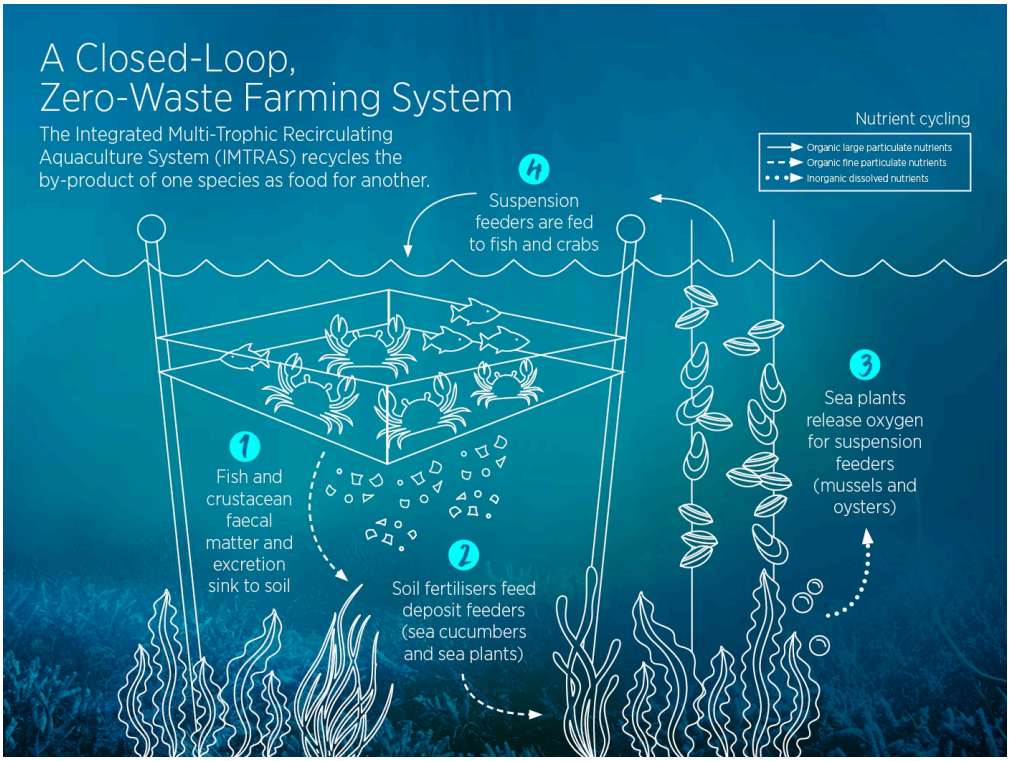
Source: ECA, based on EUMOFA (2020).

The only truly sustainable solution to the rising human population and plummeting ocean health is a shift away from all animal products and towards plant-based consumption. Realistically, this change in global consumption is incredibly unlikely, and

although we acknowledge that the global seafood market needs to shift away from fish farming, the scale of the problem, the immediacy of climate change, and food insecurity require that we aim to improve the current situation as much as we can. Integrated Multrophic Aquaculture (IMTA) is one solution, providing a more environmentally and economically sustainable alternative to traditional farming methods. IMTA integrates organisms from different trophic levels so systems can effectively recycle nutrients, with lower trophic level organisms like seaweed and shellfish cleaning the water, as seen in Figure 4.

Figure 4

Integrated Multi-Trophic Aquaculture Ecosystem



Source: Temasek (2018).

Such ‘co-cultivation’ can be seen in China, where the Sanggou Bay is an example of a success story with their IMTA farms operating year-round, producing more than 240,000 tons of seafood annually, including more than 30 species (Fang, 2016). Successful farms like Sanggou Bay have demonstrated IMTA’s ability to optimise space, improve habitat and fish health, and diversify their products. When farms’ cultivated organisms, and therefore cash flows, are diversified, business resilience increases, and communities (reliant on these incomes) support more aquaculture (OLCreate, 2021). More broadly, IMTA reduces Europe's dependency on imports by increasing local production, generating stronger local economies and employment opportunities.

Introduction

In this essay, we will discuss the barriers that IMTA integration faces in Europe and propose possible solutions for how a successful transition to a more sustainable aquaculture industry could be realised. IMTA has already attracted considerable attention from both the academic sector and regulatory bodies in recent years (Hughes, 2016; Klinger & Naylor; 2012; Diana et al., 2013; Granada et al., 2015). We will unpack why European aquaculture farmers, as a specific stakeholder, have been reluctant to make IMTA a commercial reality. Throughout this essay, we will be highlighting farmers' specific pain points in the transition towards a new and seemingly more complicated farming method (Alexander et al., 2016) and discuss possible solutions utilising insights gained through a literature review, stakeholder analysis and activity theory (Kaptelinin & Nardi, 1997).

Acknowledging these farmers as the most important actors in the industry, our analysis will also take into account the complexity of the aquaculture industry, analysing the goals and challenges of several additional stakeholders. We will focus on how the interactions of these stakeholders' needs affect the farmers.

The literature suggests that farmers' main goal is maintaining a financially viable business and that their biggest barriers to IMTA transition include profitability, a negligible legal and regulatory framework, social acceptability, and a lack of IMTA-specific knowledge and technology (Kleitou et al., 2018; Hossain et al., 2022; Potts, 2016). As of now, at least in Europe, the barriers to implementing IMTA are

perceived to far outweigh the potential benefits, with many people in the industry doubting it could be transitioned successfully:

> *"Even though I think IMTA is the appropriate thing to do, I am not sure that the industry will ever be interested in it unless it becomes mandatory. And we are very far from that possibility."* (Kleitou et al., 2018, p. 143).

Nonetheless, remedies are available to address these concerns: We will outline possible business, investment, and marketing strategies to ensure profitability for IMTA products. We will address the needed regulation from governments, how to increase social acceptability from communities and suggest education strategies to inform farmers of the new technologies and skills required for a successful transition. Lastly, we suggest creating an 'IMTA transition starting guide' for the farmers outlining all the solutions scaffolding their transition to IMTA.

1. Stakeholder and Problem Analysis

Figure 5

Problem outline and overlap with stakeholders

<table>
<tr><th>Regulators</th><th>Farmers</th><th>Consumers</th><th>Community</th></tr>
<tr><td>Unpredictability of spatial planning and licensing processes</td><td>Lack of knowledge and technology</td><td>Lack of information about benefits of IMTA-grown products</td><td>Possible regection due to destruction of local habitats and wildlife for setting up IMTA-farms</td></tr>
<tr><td>Absence of IMTA-spesific legal framework (growing two or more species together)</td><td colspan="2">Lack of demand for IMTA-grown products leads to questionable profitability</td><td>Lack of trust in governments' aquaculture decisions</td></tr>
<tr><td colspan="4">General unawareness about IMTA leads
to lack of social acceptability among all stakeholders</td></tr>
</table>

While some studies identify up to 12 stakeholders directly involved in the transition from traditional aquaculture towards IMTA (Alexander et al., 2016), we will focus on those who are most instrumental in enabling aquaculture farmers to redesign their business to IMTA. These stakeholders are: 1) Consumers: Farmers worry that there is little demand for IMTA-farmed products, especially the lower-trophic species, and therefore the costs far outweigh potential increases in revenue (Falconer et al., 2023). 2) Regulators (such as the European Commission), of whom farmers expect allyship and request more support to make the transition to IMTA feasible, specifically in the form of increased subsidies and reduced bureaucratic barriers (Falconer et al., 2023). 3) Communities: The approval and management of projects are reliant on the support and

acceptance of local communities since lack of support or active resistance can often delay or completely cancel otherwise fully approved and funded projects (Falconer et al., 2023).

1.1 Profitability

The biggest pain point for aquaculture farmers looking to transition to IMTA is the question of profitability. While uncertain profitability is an underlying theme in all aspects of the consideration of transitioning to IMTA, in this section, we will focus on the perceived lack of demand and the lack of help in terms of investment (both commercial and governmental) as the major barriers.

IMTA in the global north, especially in Europe, is still in its infancy, and, having not yet been tested in the competitive market, the financial viability of this farming method is not well understood (Kleitou et al., 2018; Potts, 2016). However, research consistently highlights the economic potential of IMTA, predicting and showcasing profitability, risk mitigation, and increased employment opportunities (Petrell and Alie, 1996; Troell et al., 2003; Whitmarsh & Wattage, 2006; Ridler et al., 2007; Knowler et al., 2020; Nobre et al., 2010; Hossain et al., 2022). Nevertheless, concerns persist over these studies' reliability and relevance to specific local and market conditions, as well as the economic model's dependency on ITMA fin-fish and lower-trophic species demand (Hughes, 2016; Kleitou et al., 2018; Potts, 2016). Additionally, the farmers worry about how to fund the initial redesign of their business and call for an upfront investment to help cover expenses such as new equipment and additional labour costs (Hughes, 2016; Kleitou et al., 2018; Potts, 2016).

1.1.1 Consumer

Considering the farmers' concern regarding a lack of demand for the produce of IMTA, a key stakeholder in this case is the consumer. Understanding consumers' pain points and openness to IMTA is therefore crucial. For consumers of seafood products, there is a clear desire for more transparency around the environmental impacts of the goods offered. However, when surveyed, respondents feel they lack sufficient information to make informed seafood purchases (van Osch et al., 2017). An Irish study found that a majority of the public doesn't regularly recognise or use ecolabels to guide their salmon purchases (van Osch et al., 2017). Research suggests that the successful acceptance of IMTA salmon by consumers relies on their ability to clearly differentiate between conventionally farmed salmon and IMTA salmon (Knowler, 2020). While recognising that the gap between expressed consumption desire and actual purchase habits is propelled by a variety of factors (Carrington et al., 2010), it is important to take consumers' reflections seriously. If customers are truly interested in shifting their consumption habits but are unaware of the disparity in nutrition and sustainability benefits of different aquaculture practices or lack the ability to differentiate between products at the supermarket, then they lack the affordances to make the appropriate consumption changes.

1.2 Lack of legal and regulatory framework

Farmers, as well as other stakeholders within the sector, identified the need to review, revise, and establish new regulatory systems for aquaculture (Falconer et al., 2023). The European Commission echoed this sentiment in their 2021-2030 "strategic guidelines

for a more sustainable and competitive EU aquaculture" and recognised the importance of the regulatory bodies to initiate the shift towards a greener aquaculture industry (European Commission, 2021). However, similar reports promising regulation change have been published since at least 2009 (Hedley & Huntington, 2009), and many farmers within the entire aquaculture industry feel a lack of support (Falconer et al., 2023), with some farmers waiting up to 10 years to receive their licence to operate (Moore, 2022).

1.2.1. Regulators

Although the European Union has supported sustainable aquaculture through the adoption of policies and initiation of research projects (e.g. Blue Growth Strategy (2012), the EU Atlantic Action Plan (2014-2020), Horizon 2020 (Marine Institute, n.d.), European Maritime and Fisheries Fund (EMFF)), the 2023 EU Aquaculture Policy Report highlights that the main challenge lies in the unpredictability of aquaculture spatial planning and licensing processes (European Court of Auditors, 2023). This assessment is echoed by the research community, which recognises planning, licensing, and regulatory hurdles as major barriers to the development and successful transition to commercial-scale production of IMTA in the EU (Alexander et al., 2015; Falconer et al., 2023). There is an overall lack of harmonisation among the different local and national regulatory frameworks and few regulations for unconventional species (e.g. macroalgae) and for growing two or more species together (Alexander et al., 2015). Scotland provides a typical picture of the regulation burden, requiring permissions from five different authorities (Blue Economy Report, 2020). Those challenges are compounded by regulators' limited understanding of IMTA

principles (given its novelty and early development stages within Europe), leading to delays in the administrative process for co-culture farm applications, further hampering the development of the sector.

Regulators must balance the priorities of various stakeholders (e.g. farmers, consumers, and local communities), including profitability, food safety, and environmental benefits. As Alexander et al. (2015) found, substantial regulatory reform, particularly the development of disease and food safety legislation, would be required for commercial expansion of IMTA. Until more robust standards are established, seafood companies are free to make a variety of claims about their 'sustainability'; many aquaculture products are already labelled with greenwashed promises of ethical consumption (Luque & Donlan, 2019), but without meaningful definitions established for the industry, these labels lack real value for consumers. Therefore, it's crucial to develop a robust regulation process that integrates science, policy-making, and labelling, enabling close communication between researchers, farmers, marketers, and regulators.

1.3 Social acceptability

Social acceptability and community support are essential for any major transition, and that remains true in the aquaculture industry; without a smooth integration of new farming methods (like IMTA), there is a high risk of failed policy proposals, substantial time delays, loss of resources, negative press, and social conflict (Shindler et al., 2002). Interviews with UK farmers highlight that a potential lack of social acceptability is of particular concern (Kleitou et al., 2018). Studies on IMTA highlight certain risks

relevant to sustainable social acceptance, particularly the risk of disease outbreaks, food safety issues, spatial and location issues, and natural disasters, which would negatively affect beaches and shared spaces within communities (Hossain et al., 2022; Potts, 2016).

1.3.1. Community

It is, therefore, crucial to consider the concerns of the communities in coastal or marine areas. Relative to other stakeholders, community members are the least aware of the details or even definition of IMTA (Alexander et al., 2016), which leads to fear of the introduction of the mysterious infrastructure which could destroy the beauty, accessibility, and tranquillity of the places they call home. The destruction of local habitats and negative impacts on wildlife are top of mind for many communities, and the risk of seaweed breaks and potentially clogged beaches full of runoff and rot are real threats (Mazur & Curtis, 2008).

Combating these concerns poses its own challenges, as these communities often lack trust in governments' aquaculture decisions (Mazur & Curtis, 2008), and different societies perceive aquaculture risks differently, which in turn must be addressed differently (Mazur & Curtis, 2008). Therefore, the public perception of the aquaculture industry is negative regarding environmental stewardship (e.g. fish diseases, nutrient pollution) and respect for local communities.

1.4 Farmers lack of knowledge

Lastly, for farmers specifically, "... factors (e.g. lack of species knowledge, expertise, and technology) were some of the most common issues raised by the farmers/scientists highlighting the additional layers of complexity of IMTA incorporation into the core

business of a fish farm and the difficulty in meeting these new requirements." (Kleitou et al., 2018, p. 144).

Uncertainty, especially during major change, can bring up many worries, and when facing possible IMTA transition, farmers express specific concerns about a lack of new species knowledge and how to farm multiple species together (Kleitou et al., 2018). They've highlighted anxiety about cross-contamination and, therefore, the impact IMTA species might have on native species and the ability to uphold food safety standards (Potts, 2016). IMTA constraints vary depending on location, such as the physical environment, weather conditions, and needs of the specific farmed species, and thus, many farmers have called for more area-specific research and guidelines (Potts, 2016). This research, as well as a more general awareness of IMTA, may help remedy farmers' general unfamiliarity and fear of transition. Therefore, farmers will need a basic understanding of new IMTA procedures, how to operate equipment, how to manage the additional species (shellfish, seaweed), disease, and everything else needed to bridge the gap between old practices and new practices. Providing a comprehensive education for farmers on how their new farms will function is daunting, but if the history of the agriculture industry (Dixon et al., 2014) is any indicator, people are more than capable of understanding complex processes, and farmers are highly adept at adapting to new systems.

In summary, the problem analysis highlights how the key stakeholders, i.e. regulators, communities, consumers, and farmers, all influence the main pain points, including questionable profitability, a lack of legal and regulatory frameworks, doubts about social acceptability and the farmer's lack of knowledge and technology, in the transition to

IMTA. This emphasises the farmers' urgent need for support from all stakeholders to make IMTA the future of aquaculture. For an overview of the farmers' pain points see Appendix B.

2. Solutions

Figure 6

Poblems & Solutions outline and overlap with stakeholders

Problem	Solution	Concepts & Theories	Steakholders Involved
2.1. Profitability & Lack of demand for IMTA-grown products	2.1.1 Two stage business strategy: 2.1.2 Increasing the price of IMTA products to create visibility and a premium feel. 2.1.3 Lowering prices to increase sales and accessibility of the products. 2.1. 4 Leveraging product diversification 2.1.5 Investments from government and private investors	- Willingness To Pay (WTP) premium for sustainable food products - Virtue signalling - Social Norms - SHIFT framework - Availability heuristic	Farmers Consumers Investors
2.2 Lack of legal framework & information about benefits of IMTA-grown products	2.2.1 Regulation by creating: - multi-species licensing - Blueprint standards (specific regulations, labelling, and licensing) - research based site allocation. 2.2.2 IMTA-labelling	- Installation Theory - (De)fetishism of commodities - Social Norms - Ecolabelling	Regulators Consumers Farmers Community
2.3 Lack of social acceptability	- Involving communities as decision makers - Spreading awareness and knowledge about IMTA benefits by trusted members of the community - Fostering trust and engagement by upkeeping the 'Social Licence to Operate' (SLO)	- Social Lisence to Operate (SLO) - Polycentric Governance	Regulators Farmers Community Consumers
2.4 Farmers' lack of knowledge	- Technical Education: workshops, area-specific research, online platform and community. - Personalised and targeted communication campaign via 'IMTA transition starting guide'	- Information Adoptation - Decision Aids	Farmers Regulators Community

2.1 Profitability

The most prominent pain point for the farmers is their doubt about IMTA's profitability. To ensure profitability, we suggest a business rollout strategy, new collaboration partners, a marketing campaign to drive demand, product diversification, and investments from governments and investors as key solutions.

2.1.1 Business Strategy

To cover the costs associated with redesigning business operations, the farmers need to have sufficient profit margins on IMTA-grown products. As stated in the problem analysis, this business redesign is unfortunately costly, which means that farmers need additional income besides their current income from fin fish sales.

We suggest a two-stage business rollout solution; the first stage involves increasing the price of IMTA products, targeting high-income customers to create visibility and a premium feel when buying IMTA. Once these products have established a place in the market, the second stage involves lowering prices to increase sales and accessibility of the products.

2.1.2 Leveraging Willingness To Pay

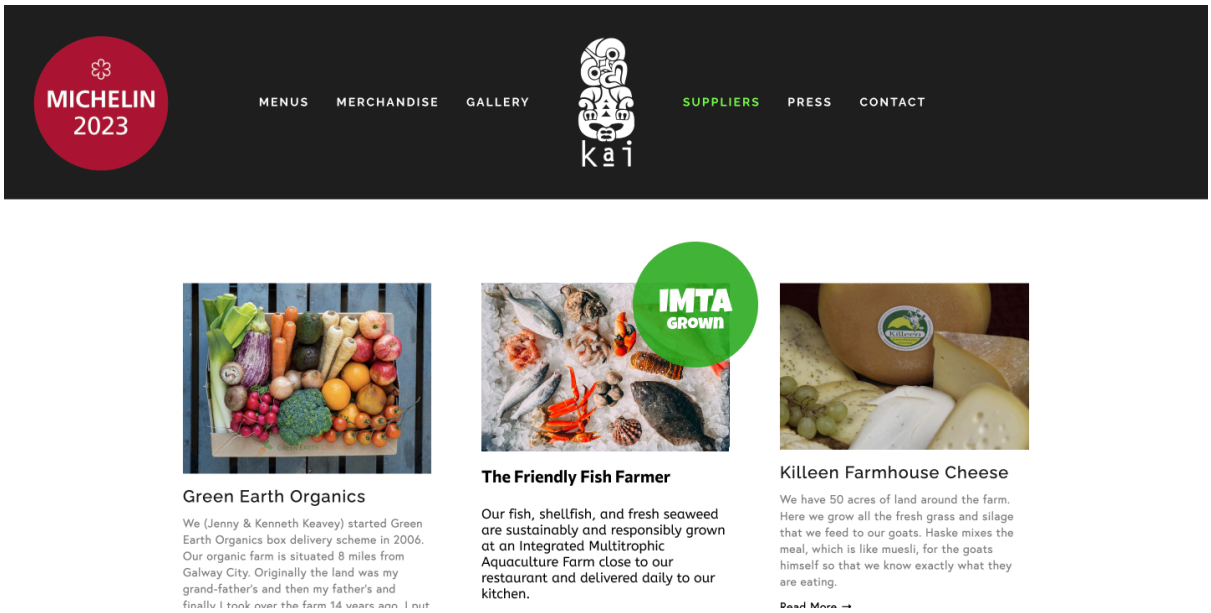
Research suggests a Willingness To Pay (WTP) premium for IMTA products in key markets (Ireland, Israel, Italy, Norway, UK) (van Osch, 2019). However, income levels significantly influence a customer's WTP, which results in reduced price sensitivity and increased WTP (Martínez-Espineira et al., 2015). Therefore, we suggest IMTA farmers initially focus on establishing local partnerships with high-end, reputable businesses

serving customers with high WTP who also expect high quality (i.e. Michelin-starred restaurants, premium hotels, food retailers, etc.). These customers make up the target group of "socio-ecological approachables" and represent the "early adopters" of sustainability products, especially in the food industry (Belz & Schmidt-Riediger, 2010). Within this stage, effective visual differentiation of IMTA-grown products as a more sustainable choice is essential because it has a significant positive effect on perceived value and, therefore on the WTP a premium (Knowler, 2020; Osch, 2019; Shuve et al., 2009; Barrington et al., 2008; Kitchen & Knowler, 2013).

Starting the business rollout with high-end, reputable corporate customers while emphasising sustainability will carry over to influence on our target consumers in the second stage. This second group, the "socio-ecological passives", make up the majority of the consumer population, and while they do not perceive ecological benefits as an extensive value added, they are highly influenced by the behaviours of early adapters (Belz & Schmidt-Riediger, 2010). In line with this, findings suggest that status competition can be used to promote pro-environmental behaviour (Griskevicius et al., 2010). Therefore, high-end customers (in this case, companies/businesses) will function as 'influencers', convincing other consumer groups that IMTA-grown products are the right purchase choice, making social expectations salient and showing others on the market how to conform (Lahlou, n.d., Chapter 8; Veblen, 1899). The aim is to attribute a pro-environmental signal with IMTA-grown products, which creates social value (Griskevicius et al., 2010). For this signal to be effective, the product must be intentionally designed to visually differentiate IMTA and mainstream products (see Figure 7).

Figure 7

Example of IMTA eco-labelling at restaurant's website



These establishments (i.e. Michelin-starred restaurants, premium hotels, food retailers, etc.) can also benefit from buying IMTA products by showcasing their dedication to sustainability and environmental stewardship by advertising their commitment to IMTA through various marketing channels (see Figure 8). This "premium feel" to IMTA will ensure a higher profit margin per fish and helps address the farmers' key pain point of IMTA's financial feasibility and concerns regarding demand in the beginning stages of IMTA farming. However, relying on only a small customer group might not be enough to tackle farmers profitability concerns and is certainly not enough to sustainably restructure the aquafarming industry.

Figure 8

Example of IMTA eco-labelling in seafood restaurants (outdoor)

2.1.3 Large-scale rollout of IMTA

This is why, for the second stage of the business strategy, we need to establish economies of scale, gradually reducing the price of IMTA while leveraging IMTA's sustainability profile and its established brand. Early adopters will have helped create a social norm through the consumption of IMTA, and their virtue signalling (Tuckwell, 2022) will ensure demand and positive perception among different segments of the population (restaurateurs, residents of communities near aquaculture facilities, and the general population) (Barrington et al., 2008).

Firstly, we suggest a focus on labelling to not just ensure convenience and visibility but to also communicate the benefits of IMTA clearly and directly. We want to make sure, however, that even if IMTA manages to make up a large part of European seafood production, it is not fully alienated from its producers and remains intertwined with the local communities and the general notion of sustainability. Marx conceptualises a

problematic byproduct of capitalism known as 'commodity fetishisation', wherein the money and merchandise exchanged in economic transactions have become completely separated from the planet and the people who produce them (Marx, 1866). While creating a label may theoretically become a fetish in itself, we believe that a label which emphasises the economic, social, and environmental conditions in which a commodity is produced also has the power to defetishise IMTA commodities, decreasing the distance between consumer and producer, which increases trust in the products and demand (White et al., 2012). Specifically, creating IMTA-labels on IMTA produce in supermarkets will target the consumer at the point of action (Lahlou, n.d., Chapter 10) by highlighting sustainability and nutrient benefits on packaging (see Figure 9) and in shops (see Figure 10).

Figure 9

Example of IMTA-grown salmon label

Source: adapted and developed from Osch (2019).

Figure 10

Example of IMTA eco-labelling in grocery stores

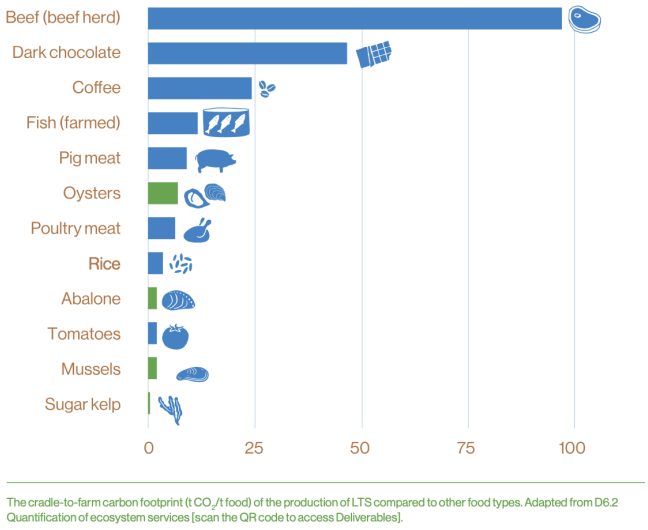
The label should focus on credence attributes: quality characteristics, which cover aspects like food safety, nutrition, production, and processing methods, because this highlights the positive and unique benefits of IMTA (Wessells, 2002). To increase consumer demand, the label should include attributes such as location of production (like local farms) and level of sustainability (like farms' nitrogen and phosphorus waste levels) (Osch, 2019). Creating a label focused on promoting pro-environmental benefits in a public consumption setting (restaurants, hotels, retailers) also influences consumers' desire to align their values and actions by buying more sustainable product options (Peloza et al., 2013).

In addition to an "IMTA-grown" label, the demand for seaweed in Europe must be addressed because it is not a typical part of the western diet (Losada-Lopez et al., 2021), as opposed to shellfish and fin fish. Seaweed (sugar-kelp) has a very small carbon

footprint relative to other food types, so will benefit sustainability goals most (see Figure 11).

Figure 11

The carbon footprint of the production of low trophic species compared to other food types



Source: AquaVitae (2023).

Customer acceptance of seaweed is highly influenced by taste and familiarity (Losada-Lopez et al., 2021). Therefore, we suggest farmers to organise workshops, where chefs present flavourful recipes using low trophic species (LTS), especially seaweeds, giving the customers the opportunity to taste the produce. Leveraging the availability heuristic, it has been shown that offering simple recipes and tasters in grocery stores featuring IMTA ingredients (Engler, 2023), as well as emphasising the health benefits of shellfish has been shown to increase sales (Piazza & Loughnan, 2016).

A combination of these solutions in the second stage of the business plan will help bridge the gap between consumer and producer, which should increase trust in and

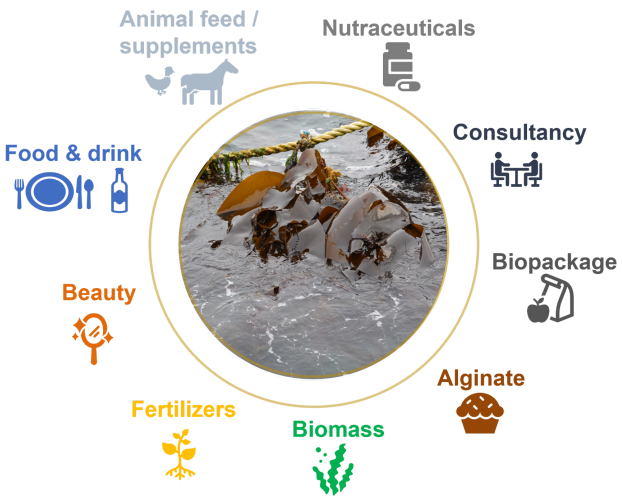
knowledge of the benefits of IMTA products, driving demand and profitability (White et al., 2012).

2.1.4 Leveraging product diversification

IMTA's additional outputs (mainly seaweed and shellfish) have their own distinct markets, allowing for the diversification of revenue streams for farmers. Another important way to increase demand for alternative IMTA products is by exploring alternative markets for these products (see Figure 12).

Figure 12

Overview of the main products/services provided by seaweed-related businesses in the UK



Source: Marine Science (2022).

Seaweed, for example, has the potential to play a hugely important role in food chains and is already used as fertiliser, animal feed, in food processing, and as a low-carbon, nutrient-dense food source (Fallon et. al., 2022). It's not just used for the food cycle,

though; in the UK alone, seaweed-related businesses have more than doubled since 2016, with seaweed being used to produce cosmetics, pharmaceuticals, packaging, and even snowboards (Capuzzo, 2022). In recent years, the shell industry has been equally innovative: oyster shells have been used in a wide variety of products. For example, oyster farms and a local factory in France have partnered to use shell waste to make products like cattle feed, fertiliser, road paint, 3D printer filament, and soles for shoes (Burch et al., 2019). Supporting collaboration between farmers and innovative companies, as those mentioned above, would provide new opportunities for income from IMTA products and help address the profitability pain point. This could happen through information campaigns targeted at the farmers and the companies.

2.1.5 Investments from governments and investors

The business plan mainly addresses how to create a viable business for IMTA farmers, however, they need help with the initial investment to address the pain points of buying new technology and equipment. Studies paint a promising picture of long-term financial viability for IMTA, but the initial investment and infrastructure restructuring can be daunting (Hossain et al., 2022). Relative to Asian polyculture and modern shrimp and fish monoculture, IMTA is a new concept and farmers require targeted financial support from governments and investors. For example, producers could be compensated by governments through loans and subsidies, or paid directly for organising their activities in ecologically beneficial ways (Hu et al., 2021). The Environmental Land Management scheme in the UK (Department for Farming, Environment and Rural Affairs, 2021) (Fallon et al., 2022) has done exactly this with

land-based farming techniques. Because IMTA provides higher ecological benefits over traditional aquaculture, farmers making the switch would benefit from direct payments from the government (if the same financial awards outlined in the Land Management scheme were applied to aquaculture).

Secondly, funding could come directly from private entrepreneurs and investors. However, because IMTA is often perceived as a large risk, guaranteed government loans and subsidies are likely a precursor (Knowler, 2020). Although the details of increasing private investment are outside the scope of this essay, preliminary research suggests that if legislative changes are established to address logistics like permit coordination and technical viability at commercial-scale production, then economic gains will be more certain and private investment will follow (Falconer et al., 2022).

2.2 Lack of legal framework Regulation

2.2.1 Regulation

For policymakers to engage with farmers, setting regulation agendas for prioritising IMTA is identified as a crucial step for transition (Ellis & Tiller, 2019). The 2021-2030 strategic guidelines for more sustainable and competitive European aquaculture (European Commission, 2021) have committed to developing aquaculture systems with lower environmental impact.

The activity grid (see Figure 13) for regulating IMTA emphasises key suggestions to guide a framework for the licensing process, such as creating multi-species licensing, blueprint standards (including specific regulations, labelling, and licensing), and open

spatial planning (research based site allocation), all aimed at supporting the commercial adoption of IMTA practices.

Figure 13

Activity Grid for Regulators facilitating IMTA

	Actor: Regulators			Installation		
	Motives & Goals	Contributions	Rewards	Affordance	Competence	Regulation
Multi species licensing	Make it possible to establish an IMTA site	1. Revision of national licensing systems for consistency in requirements. 2. Address persistent concerns around commercial-scale IMTA (disease transfer, fish health and food safety).	Overcome barriers that underpin the delopment of IMTA on commercial scale and, as a result, sustainable development of aquaculture.	1. Develop licensing systems that permit multiple species and activities. 2. Enable ecosystem management approach, including social and technological considerations.	1. Regulators develop and maintain workforce knowledgeable in IMTA practices. 2. Regulators work closely with IMTA pilot farms (research sites), ensuring a continuous integration of science into policy.	1. Develop *IMTA-specific food safety legislation*. 2. Require farmers to gain a *SLO* to ensure community interests are included. 3. Create an IMTA-specific labelling system. 4. Require constant Fish Health and Food Safety monitoring of farms.

Regulation	Make the degree of environmental impact acceptable	Economic and environmental feasibility studies in national and regional contexts (technical, biological, and economic viability at commercial-scale production)	Minimise environmental footprint of IMTA operations.	1. Develop Blueprint standards: IMTA-specific licensing, regulation and labelling standards. 2. Create mechanisms for continuous monitoring and assessment of environmental impacts utilising IMPAQT soultions.	Ensure that regulatory agencies understand the nuances of IMTA operations and make decisions that balance ecological concerns with economic viability.	1. Establish clear, consistent, and enforceable regulations that support the sustainable scaling of IMTA operations. 2. Develop regulations that set acceptable limits on environmental impacts from IMTA operations, with provisions for mitigation and penalties for non-compliance.
Open Spatial Planning	Consider technical, biological, and economic viability of commercial-scale production.	Research-based assessment of site selection and market demand.	1. Avoid combinations of species and trophic groups inappropriate in specific areas. 2. Enforce the financial sustainability of farms.	Providing access to relevant data for site selection, such as oceanographic, environmental, and socio-economic data, to assist in making informed decisions about the location of IMTA farms.	1. Ensure that regulatory agencies have the expertise to analyse site assessment data. 2. Provide guidelines for species selection and management practices appropriate for each designated area to maintain the sustainability.	1. Permit demonstration sites for collection of research-based data and further advancement of the IMTA (proof-of-concept to stimulate investment) 2. Develop regulations that define where IMTA farms can be established based on comprehensive environmental impact assessments and market analyses.

Sources: Alexander et al. (2015); Falconer et al. (2023); Lahlou et al. (2022)

This framework should be created in collaboration with all stakeholders to ensure trust and accountability (Ostrom, 2010). For example, Fisheries Local Action Groups (FLAGs) can serve as intermediaries between local regulators and farmers eager to transition to IMTA systems by identifying effective solutions across the European farm network and offering information to update legislation. A clearly defined and explicit regulatory framework would streamline the licensing process and ensure a well-grounded transition.

2.2.2 Labelling

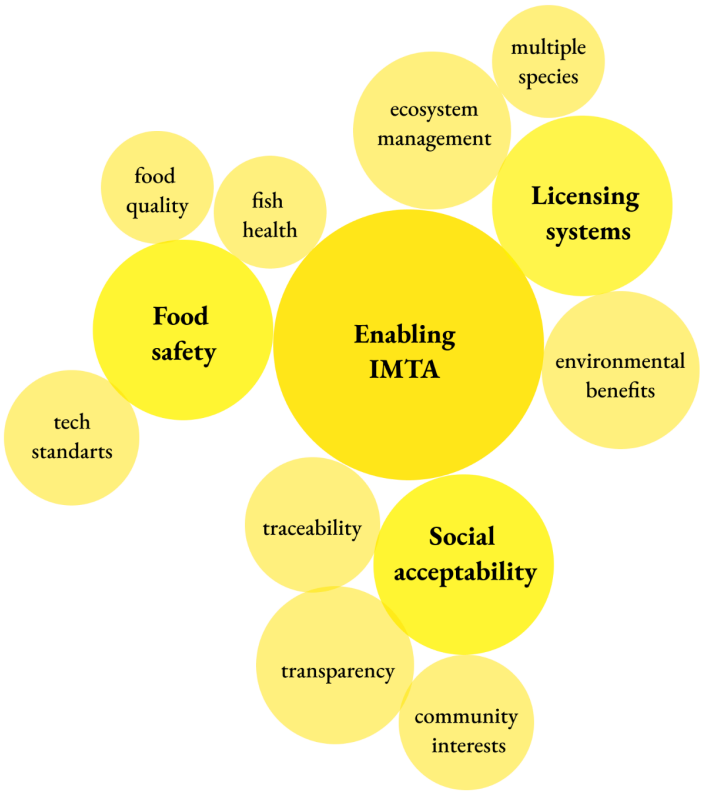
IMTA's lack of a supporting legal framework also prevents meaningful labelling. Currently, there is no consistent system for recognising and rewarding sustainable aquaculture-specific practices (Blue Economy Report, 2020). Labelling schemes have the potential to acknowledge IMTA's value to the natural ecosystem, but they require governmental support (Johnston et al, 2001; Osch, 2019). Regulators should use ecolabels as a policy instrument to stimulate more environmentally friendly production to reach policy goals.

We suggest that regulatory bodies work closely with researchers to create clear and simple accreditation guidelines to obtain the IMTA ecolabel. One example would be to use data from the EU-funded IMPAQT project (Marine Institute, n.d.), which holistically considers food safety, food quality, health impacts, animal welfare, and sustainability. IMPAQT also comprehensively evaluates environmental, social, and economic indicators. When assessment is based on verified and standardised

methodologies like the IMPAQT review, farmers' confidence in their ability to uphold food safety standards will be boosted (see Figure 14).

Figure 14

Enabling IMTA: Key Aspects for Regulation to Emphasise



2.3 Social Acceptability

2.3.1 Communities and Social Licence to Operate

To address farmers' concerns about social acceptability from their communities, we suggest involving communities in the transition to IMTA. This involvement entails

multiple components, including increasing awareness and knowledge of IMTA, fostering trust, and engagement (see Appendix C).

2.3.2 Awareness and knowledge of IMTA

As addressed earlier, communities often lack awareness of IMTA, fear potentially harmful environmental effects, and mistrust government messaging on aquaculture. As a first step, we suggest that spreading awareness and knowledge about IMTA benefits, such as nutrient recycling, food safety, and the possibility of new job creations (through the labour needed to farm additional produce, like shellfish and seaweed), can be leveraged to increase community support for IMTA. Awareness and knowledge should be spread by trusted members of the community who have respect, status, and an understanding of the local socio-environmental, political, and economic context, as this will increase the effectiveness of the communication (Lahlou, n.d., Chapter 8). When communities' concerns about environmental pollution from the industry are addressed and people are made aware of the socioeconomic benefits of certain aquaculture, support can increase (Katranidis et al., 2003).

2.3.3 Fostering trust and engagement

However, to reach a sustainable solution for community acceptance, there is a need for more than just spreading awareness. The aim should be to maintain ongoing acceptance of business practices, also known as upkeeping the 'Social Licence to Operate' (SLO) (Brooks, 2016). Various global studies cited in Mazur & Curtis (2008) have shown that when the values and needs of local communities are "incorporated into aquaculture planning before development, the industry's social, economic and environmental

sustainability could more easily be secured" (Mazur & Curtis, 2008, p. 603). Therefore, we suggest empowering the community by involving them in the transition to IMTA. For example, citizen advisory committees and citizen juries could take part in meetings when regulators develop new licensing or space allocation plans. Governmental institutions should work closely with farmers and their communities to generate collaborative solutions and transparent ways of monitoring the transition, as this will develop trust (Ostrom, 2010) and increase the likelihood of sustainable SLO (Brooks, 2016).

2.4 Farmers' lack of knowledge

2.4.1 Technical Education

Targeted programs aimed at demystifying IMTA can equip farmers with the tools they need to redesign their businesses. Workshops organised by regulators (or local government in collaboration with researchers) filled with practical knowledge on species selection, tailored to local conditions, can dispel concerns about cross-contamination and environmental disruptions. Farmers participating in these training sessions would learn the best practices for managing a multi-species ecosystem and gain confidence in IMTA as a whole. Area-specific research addressing their unique challenges and environmental constraints will further solidify their trust, paving the way for wider adoption (Føre et al., 2018).

To further raise awareness about the benefits of IMTA, it is vital to build a community around it from interested farmers, local authorities, and coastal citizens by introducing founded by government with information support from IMTA-reserach cites a project

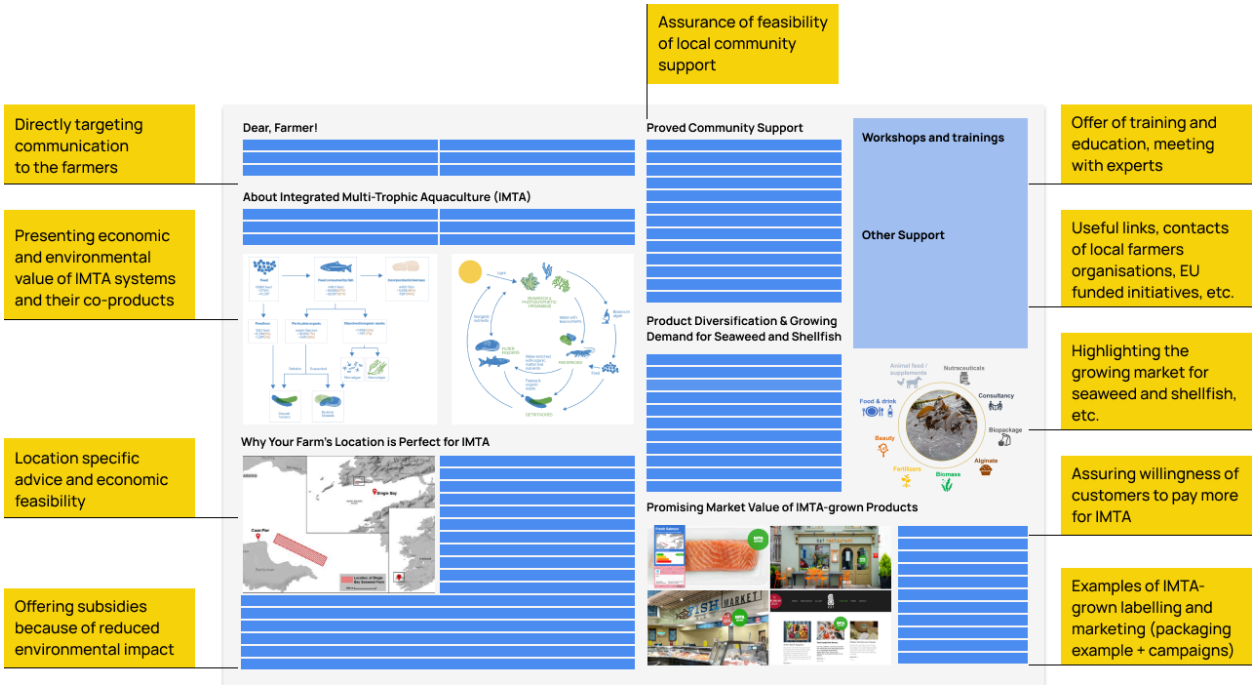
similar to the Green Wave project in the US (*Green Wave*, n.d.). It has received widespread recognition for making IMTA easy and affordable by offering guidance and assistance with legal and permit matters, technical challenges, equipment, and marketing strategies.

2.4.2 Communication

"Nothing in science has any value to society if it is not communicated." (Roe, 1953, p. 17)

Figure 15

A template of an 'IMTA transition starting guide'



Throughout this research, one of the excruciatingly prevalent findings has been a clear lack of communication with those who are expected to implement IMTA: the farmers. We believe that engaging farmers and communicating relevant information on research,

regulation, and technology is key to addressing farmers' concerns and showcasing the benefits of IMTA.

To efficiently communicate information about IMTA to the farmers, we have designed a template of an 'IMTA transition starting guide' (see Figure 15), outlining farms' potential to become more profitable through IMTA. This could be used by regulators to initiate contact with farmers who, based on their location and current procedures, are feasible prospects to transition to IMTA.

These leaflets can be designed with cognitive psychology in mind, using symbols and visual information to ease navigation (Renuka & Pushpanjali, 2013), decision aids (helpful images) to encourage the reader to make quicker decisions (Todd & Benbasat, 1992), and short sentences with the information presented in 5-9 chunks, so that key information can be easily retained in the short term memory (Murata et al., 2001). Ideally, these leaflets will support farmers' transition to IMTA in a concise and approachable way.

3. Discussion & Limitations

There are multiple limitations to our research. First and foremost, as acknowledged in the introduction, IMTA is merely a way to make eating fish (marginally) more sustainable. IMTA has its own risks of habitat destruction, pollution, and food safety, which we left largely unacknowledged due to the essay scope, but these risks are important to study further as IMTA's popularity increases. Ideally, IMTA will ease consumers' transition from the currently unsustainable levels of fish consumption towards other sea produce and plant-based foods while alleviating some environmental harm in the meantime.

Secondly, a more extensive stakeholder analysis, while exceeding the possible scope of this essay, would have led us to an even deeper understanding of the problems in the industry. Because we focused on only four stakeholders and channelled the farmers' perspective specifically, we lacked an extended comprehension of the goals and pain points of other parties.

Furthermore, we are aware of our proposed solutions' heavy reliance on regulators to facilitate change. Some changes will require a large financial investment, which will be difficult to procure. Other solutions, like the personalised pamphlet, exceed the scope of how governing bodies normally operate, and any bureaucratic changes are likely to involve time-consuming, resource-intensive processes. Tackling the government's inability to efficiently promote positive change is outside the scope of this essay.

While the research and literature reviews we referenced were tremendously helpful, we did not personally visit an aquafarm nor conduct any type of firsthand research. In the future, direct contact with farmers would allow us (or other researchers) to ask detailed questions, understand the differences in local demands, and discuss the proposed solutions with farmers directly.

Once farmers are able to successfully transition, the biggest threats to IMTA's ongoing success include reduced or insufficient public funding, reduced social licence (as IMTA scale increases), misinformation, potentially lower profitability in the short term compared with existing aquaculture systems, and an inability to adjust to or sustain output amidst climate change induced disease, parasites, storms, or other unforeseen climate effects (Blue Economy Report, 2020).

Conclusion

The fishing industry has major sustainability problems, with wild fishing causing massive species extinction, ecosystem destruction, intensified hurricanes, and accelerated melting of Earth's major ice sheets. Aquaculture has alleviated many of the consequences of wild fishing, but the metal structures, pharmaceuticals used, restricted movement of the fish, and faecal contamination adversely affect both the health and nutritional value of the fish and have detrimental effects on marine ecosystems. IMTA addresses major problems with mainstream aquaculture. However, the transition to this new method of farming is problematic due to its novelty in the global north. This essay has centred on the farmers' key pain points of this transition, analysed with an in-depth stakeholder analysis using activity theory, and an extensive literature review, and proposed solutions for how the key stakeholders can help address aqua farmers' main pain points. We propose ways of increasing profitability, creating an effective and adaptable legal and regulatory framework, increasing social acceptability, and educating aqua farmers with specifics on how to redesign their business to an IMTA farm. We argue that a successful transition to IMTA is not just advantageous for farmers; it is an investment in a more sustainable future for all stakeholders.

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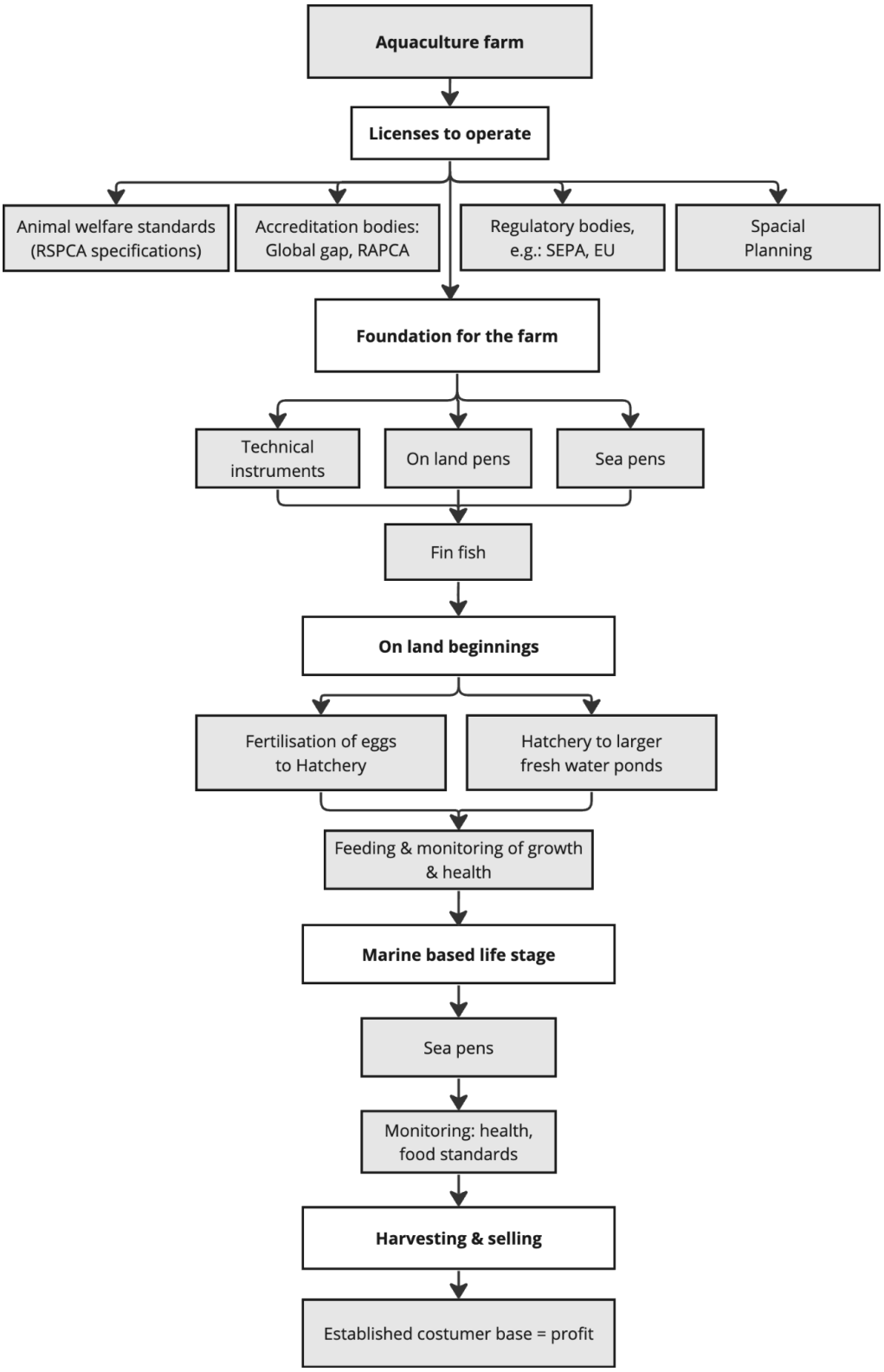
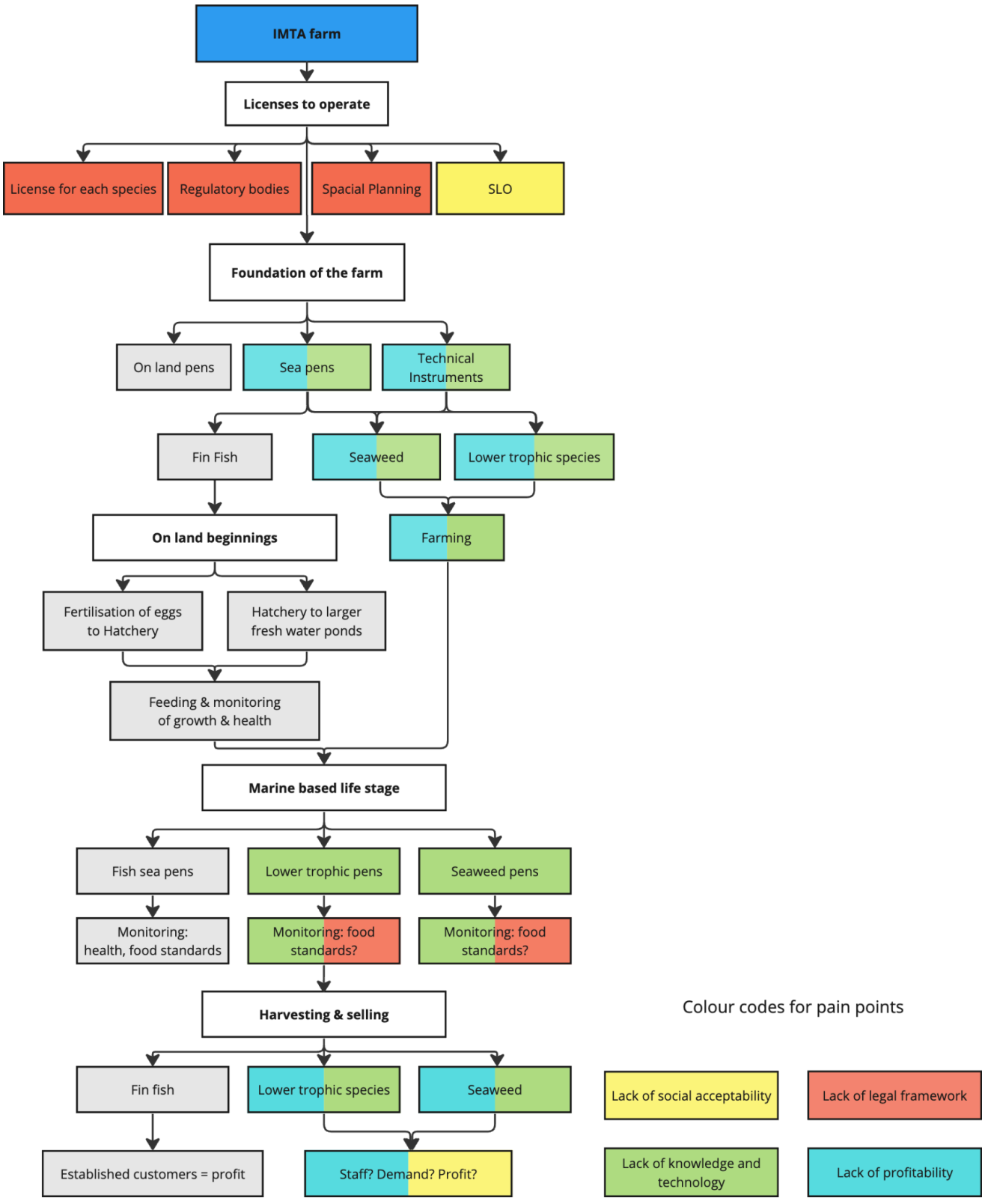
Appendix A. Flowchart for current aquaculture practises



Appendix B. Flowchart for Farmers transitioning to IMTA (with pain points)



Appendix C. Activity Grid for Engagement with Community as Part of Gaining Social Licence to Operate.

	Inform	Consult	Involve	Collaborate	Empower
Action	Provide information about IMTA benefits. Educate about economic, social and environmental advantages for community.	Ask for initial thoughts and feedback.	Identify interested community members for collaboration throughout the transition to IMTA.	Invite community members to make decisions and problem solve.	Implement community decisions.
Goal	Provision of information to raise awareness and facilitate balanced interpretation	Collect feedback and integrate it into further communication.	Gain trust of influencers within the community to reach shared motives and address contradictory perspectives.	Work directly with groups with the aim of shared understanding.	Organise into seafood commons to place a substantial part of decision-making in the hands of the community.
Tools	Fact sheets, Leaflets, Presentations, Websites, Information Stands.	Public comment, Focus groups, Public meetings, Open houses.	Workshops, Deliberative polling, Joint projects & Initiatives.	Citizen advisory Committees, Consensus building, Community partnerships, Advisory panels	Citizen juries, Ballots, Delegated decisions, Co-ownership, Including community as stakeholders in the governance structure of farms.

Sources: Adapted and developed from Brooks (2016), Billing (2020).