Aquaculture 588 (2024) 740926

Contents lists available at ScienceDirect

Aquaculture

journal homepage: www.elsevier.com/locate/aquaculture

What affects the level of local social acceptance of salmon farming in Norway?

Katrine Eriksen *, Eirik Mikkelsen

Industrial Economics Department, The Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima), Muninbakken 9-13, Breivika, Postboks 6122, NO-9291 Tromsø, Norway

ARTICLE INFO

Keywords:
Environment
Fish farming
Social acceptance
Structural equation modelling

ABSTRACT

The concept of a social licence to operate (SLO) that first emerged related to mining has been developed into several strands of theoretical models and used to study the social acceptance of industries in different contexts. There is an emerging literature on SLO for salmon-farming, but very few quantitative analyses are done to identify and assess factors that affect the level of social acceptance. Models that explain social acceptance levels from people's trust in an industry or company, their confidence in governance, and views on procedural and distributional fairness (trust models) are designed for quantitative analysis, and they have been successful in explaining social acceptance levels for mining. In this paper, we use survey data to test whether the factors in trust models can also explain the level of local social acceptance for salmon farming in Norway. From the structural equation modelling analysis, we conclude that these models at best have limited explanatory power in our case. We then develop an alternative model to analyse social acceptance, where factors of perception and attitudes and respondents' individual characteristics are tested as direct regression paths to influence level of acceptance. This model explains the variation in the data well. The factors that most strongly affect the level of acceptance, and which industry or authorities also can influence, are the perception of to what degree aquaculture is environmentally sustainable, whether the industry acts according to society's expectations, and if the industry is trustworthy. Practical implications for the industry and governance are discussed.

1. Introduction

Developing industrial activities can crucially depend on good relationships with the local communities where the activities will take place and having their trust and acceptance. This is especially relevant for extractive industries and other large-scale production that affect land- and seascapes and have significant environmental and social effects locally. At the same time, such industries often generate large benefits to actors outside of the local communities. This geographical imbalance of risks, costs and benefits can be a source of controversies. As local expectations and requirements to companies are rising (Vanclay and Hanna, 2019), failing to gain social acceptance can result in substantial costs for the industries due to interruptions (Moffat et al., 2016; Owen, 2016) and in some cases termination of projects (Jijelava and Vanclay, 2018).

Different approaches to study the relationships between local stakeholders and industrial actors have been suggested. The concept of *legitimacy* is perhaps the most widely used and is defined as the extent to which the project is justified by the existing formal and informal rules, norms and beliefs (Gehman et al., 2017; Meesters et al., 2021). *Corporate social responsibility* is a narrower concept that also encompasses many of the aspects related to legitimacy and acceptance (Latapí Agudelo et al., 2019). In the early 2000s, a body of literature emerged around the concept of *Social Licence to Operate* – SLO (Santiago et al., 2021). The definitions of SLO in the literature explain it as affected communities' level of acceptance of an industry or company (Moffat et al., 2016).

The term first appeared within mining industry groups (Thomson and Joyce, 2008) and has later been adopted in the scientific literature related to mining and other sectors, including the marine sector (Kelly et al., 2017). It is however, for the studies of mining it has been further developed and conceptualised. Although the term likely started out as a metaphor for communities' abilities to stop industrial projects (Boutilier et al., 2012), it has since been developed further with efforts to model and measure SLO. Despite continued conceptual discussions about the metaphorical nature of the SLO concept (Duncan et al., 2018; Hitch and Barakos, 2021), with the models to measure it, SLO has been considered

* Corresponding author.
E-mail addresses: katrine.eriksen@nofima.no (K. Eriksen), Eirik.mikkelsen@nofima.no (E. Mikkelsen).

https://doi.org/10.1016/j.aquaculture.2024.740926
Received 20 April 2023; Received in revised form 14 March 2024; Accepted 6 April 2024
Available online 9 April 2024

a useful management tool within e.g., the mining (ibid.) and petroleum industries (Jijelava and Vanclay, 2017). This formal approach has yielded several models to analyse SLO, which in various ways include possibilities for quantitative analysis (see Gehman et al. (2017) for a comprehensive review). With means to measure the level of social acceptance and to analyse which factors that affect that level, SLO goes from being a metaphor and into a useful tool for handling industry-community relations through trying to influence those factors. One of these groups of models has several latent factors that can affect acceptance levels, where the trust in the industry is central (Zhang et al., 2015). Thus, we refer to them as trust models in this study.

The attention to social acceptance as a prerequisite for successful industry development has been increasing in the aquaculture sector. For aquaculture, which has been the fastest growing food production sector globally (Garlock et al., 2020), public risk perceptions have been found to outweigh cost-benefit evaluation as an indicator of growth potential (Anderson et al., 2019). Research on the social acceptance of aquaculture has been broad and methodologically diverse. Attitudes towards aquaculture have been studied primarily using qualitative methods and descriptive statistics (Flaherty et al., 2019), including analysis of media coverage (Kraly et al., 2022; Olsen and Osmundsen, 2017; Weitzman and Bailey, 2019). Modelling and measuring of acceptance level and relationships between acceptance factors is relatively rare in this literature, except for willingness-to-pay (WTP) surveys (Grimsrud et al., 2013; Aanesen et al., 2022; Aanesen et al., 2018) and Q-method studies (Bacher et al., 2014; Britsch et al., 2021). Regression models are sometimes used to explore the factors influencing public support of aquaculture (Dalton and Jin, 2018; Weitzman et al., 2022). The studies use slightly different definitions of SLO and stakeholders' acceptance. A recent review on the study of SLO in aquaculture (Whitmore et al., 2022) identified and discussed factors of acceptance without prioritising any existing SLO frameworks. The use of the SLO concept as it was developed in extractive industries has been scarce and mostly descriptive (Alexander, 2022; Billing, 2018; Billing et al., 2021; Leith et al., 2014). An exception is the recent study by Chico et al. (2022) which presented a path model of aquaculture acceptance in Spain, where the two latent constructs define acceptance of product and companies. Interestingly, this study did not explicitly refer to the previous SLO modelling approaches. Trust models have been applied to aquaculture in New Zealand (Sinner et al., 2020), where quality of contact with the companies was found to be strongly associated with public acceptance, while perceptions of environmental, economic and social impacts were not significant predictors.

An application of the SLO concept, including modelling and measuring relationships between its elements, is useful to study aquaculture acceptance in a methodologically systematic way. However, models developed for extractive industries may not be applicable for aquaculture, which differs in many ways from other economic sectors (Alexander, 2022).

The purpose of this paper is twofold. Firstly, we test the trust model framework in a study of social acceptance of aquaculture in Norway. Secondly, we identify important factors for people's social acceptance level for aquaculture in Norway. The novelty of this research is in the application of the trust models to study SLO for aquaculture. As SLO is concept is increasingly taken up by aquaculture research and governance (Mather and Fanning, 2019), it is a timely and relevant contribution to a better understanding of the concept and its potential for addressing controversies of the aquaculture growth.

The data on people's perceptions of distributional fairness, communication, trust in governance and trust in the aquaculture industry were obtained from a survey in two Norwegian counties. We estimated structural regression coefficients and assessed the model fit statistically. We then compare these estimates with the output of an alternative model of SLO, where measured variables explain the level of acceptance directly. We found that the alternative model better explains the level of acceptance, which means that the structural relationships between the factors in the trust models do not fit well to the aquaculture context. Finding a suitable model for SLO in aquaculture sector can be a subject for future research.

The results suggest that the most important factors for the local social acceptance of aquaculture in Norway are perceptions on the environmental sustainability of aquaculture, trust in the aquaculture industry, confidence in the authorities' governance of the industry, and fair distribution of benefits from the industry. To increase the social acceptance, the aquaculture industry and the authorities should prioritise working with these aspects.

The paper proceeds as follows. The background section shortly outlines the development of the SLO concept in the literature and summarizes previous findings on social acceptance of aquaculture in Norway. Section 3 describes the method and model estimation procedure. Results are presented in Section 4. The following section discusses possible explanations for our results, limitations of the study, implications for industry and authorities and for future research on SLO in aquaculture. Finally, a short conclusion is presented.

2. Background

2.1. Theoretical framework

Gunningham et al. (2004) made an early academic contribution on the social licence to operate. They described how companies originally saw their social obligations as being limited to fulfilling the legal requirements for operation, but since then corporation executives increasingly have talked about operating in accordance with their social licence. The expectations were perhaps that the demands from community groups and NGOs will sooner or later lead to government action and legal liability. Thus, the authors defined the SLO as the local stakeholders' demands governing the constraints in which the industry operates, even if these constraints are not formally established by law. According to Gunningham et al. (2004), SLO reflects the willingness of companies to act "beyond compliance", or legal licence, with regard to environmental protection and social impacts. According to this model, the companies are also limited by an "economic licence", meaning the requirement of profitability, which in turn defines how far the company can go beyond legal compliance to fulfil demands of positive social impacts and environmental protection. A similar principle of different licences was adopted in the "triangle-model" of renewable energy technology acceptance (Wüstenhagen et al., 2007). In this model, a social licence consists of local community acceptance that facilitates local realisation of renewable energy projects, socio-political acceptance that underpins general societal support for renewable energy production, and market acceptance meaning that the energy produced finds its consumer.

The *Pyramid model* (Boutilier and Thomson, 2011) relates different levels of a social licence to operate with boundary criteria to achieve those levels of SLO. The lowest level corresponds to withholding or withdrawing of SLO. If the industrial activity is considered *legitimate*, it can gain *acceptance* as the next level of SLO. If it is seen as *credible* it can get the SLO-level of *approval*. If the company earns *full trust* from the local community, the community goes into a mode of *psychological identification* and psychological co-ownership with the company. These SLO boundary criteria have been investigated and operationalised. In a study of mining acceptance in Bolivia, the SLO levels were measured using a questionnaire and presented by averaging scores (Boutilier and Thomson, 2011).

According to Thomson and Joyce (2008), SLO exists on several organisational levels, where acceptance on the project level promotes acceptance on the corporate and industry level. Some authors defined SLO for a product separately from that of a company or industry (Chico et al., 2022).

Within the metaphorical view on SLO, qualitative methods are normally used to study the phenomenon. More recently, however, SLO modelling have been using quantitative methods, where strength of the relationships between SLO constructs are measured.

One group of quantitative models explains the level of SLO as depending on the trust local communities have in companies and the governance system (Zhang et al., 2015). SLO are in these *trust models* analysed using path analysis principles, where SLO and trust levels depend on perceptions in the local community of *distributional fairness*, *procedural fairness*, *quality of dialogue*, and *confidence in governance*. Measures of these constructs are obtained via surveys and often analysed statistically using Structural Equation Modelling (SEM) techniques. Trust models have mainly been applied in studies of the mining sector (Mercer-Mapstone et al., 2018; Moffat et al., 2016; Zhang et al., 2015). Studies applying trust models found that the relative influence of factors explaining SLO varies between contexts. Zhang et al. (2015) suggested that socioeconomic, legislative and political systems, as well as the histories of the people who live within those societies determines these systematic differences.

There is clearly a variation and flexibility in the SLO literature in conceptualising and measuring social acceptance. Different models are combined and adjusted to the problem at hand. Trust models are however the most advanced in their approach to refining the concept and quantifying SLO, and this gives them potential for application to a wider range of industrial activities. Although social acceptance is an issue relevant for many companies and industrial sectors, it is uncertain to what degree the SLO concepts developed in the context of mining, including trust models, are applicable to other sectors and settings.

2.2. Norwegian aquaculture industry

The aquaculture sector in Norway is dominated by Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) farming in open sea cages. Norway is the dominant global producer of Atlantic salmon, with >1.5 million tonnes produced in 2022. Current production volume is roughly a threefold increase since 2000 and more than eight-fold increase since 1990 (Fig. 1). The development of the Norwegian salmon farming industry has been economically very successful since it started as small-scale farming around 1970 and now has grown to be one of Norway's largest export industries, with an export value of 128 billion NOK in 2023 (ca. 11.2 billion Euro). About a thousand production sites are in operation along the coast, with highest concentration in the south-western part of the country.

The production of farmed salmon in Norway has had fast growth for decades, but between 2012 and 2018 it stagnated due to environmental problems causing the authorities to limit the issuing of new licences. It has since increased somewhat. There are however ambitions for a substantial growth in the next decades, supported by both industry and the government. The expansion is anticipated mainly in Northern Norway, partly due to lower density of farms there (Aanesen and Mikkelsen, 2020).

The total number of companies in grow out production of salmon (from juveniles to market size) was 165 in 2022, while 115 companies operated in production of juveniles (smolt). The industry directly employs about 8800 people according to the Directorate of Fisheries (Fiskeridirektoratet, 2022), but many more when ripple effects are considered (Nyrud et al., 2023).

Since the 1970s, aquaculture has provided employment opportunities in rural coastal municipalities, where the number of jobs in fisheries and the fish processing industry has been in steady decline (Hersoug, 2021; Iversen et al., 2020). As the industry has developed, ownership has become more concentrated, slaughter and processing facilities have been reduced in numbers, and the local workforce needed to operate the farms has been reduced through automation and remote-controlled feeding systems. This has led to a more skewed distribution of profits, jobs, tax income and other local benefits between municipalities (Aanesen and Mikkelsen, 2020). Together with the environmental risks of salmon farming, some municipalities had little willingness to set aside more areas for this activity in their coastal zone plans (Jørgensen and Nordgård, 2023). New aquaculture sites must be placed in accordance with municipal coastal zone plans, so the municipalities' attitudes are key for continued growth of the industry.

To make sure that all municipalities with salmon farms in their coastal waters get some economic benefits, and to stimulate the municipalities to allocate more areas to salmon farming, an Aquaculture Fund was established and made its first payments to municipalities in 2017 (Misund et al., 2023). It has distributed a share of the fees paid for new salmon aquaculture production capacity to the municipalities, based on the municipalities' shares of the site production capacity. In addition, municipalities will get a 50% share of the resource rent tax that was introduced in 2023.

One of the main challenges to achieve further growth in the sector is to reduce the environmental impacts of salmon farming, especially on wild salmon stocks, where spread of the parasitic salmon lice and escapes of farmed salmon are the most pressing issues, considered as "non-stabilised" threats to the wild populations of salmon (Forseth et al., 2017; VRL, 2022). Aquaculture might also affect marine species and ecosystems via organic pollution and the use of chemicals, where de-

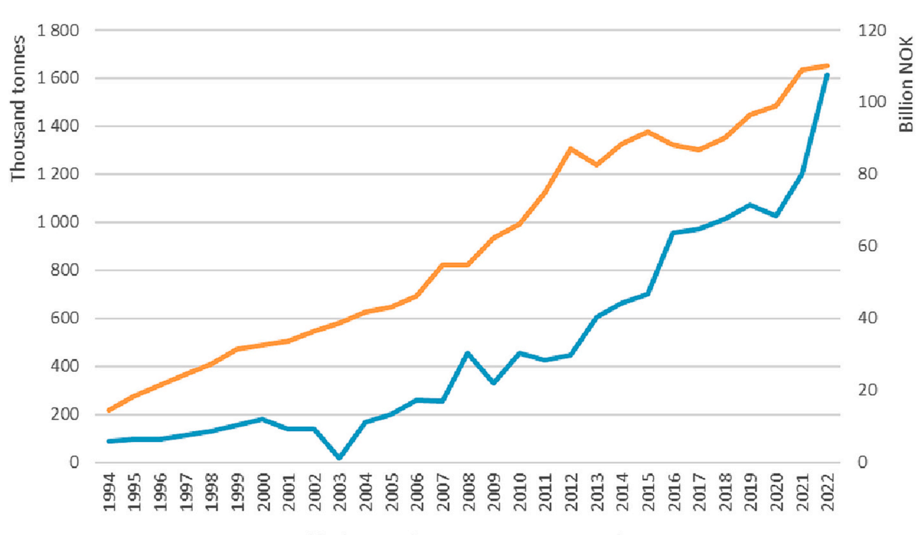


Fig. 1. Sold salmon and rainbow trout produced in Norway (tonnes, WFE - whole fish equivalent) and value from 1994 to 2022 (1000 NOK). Source: Norwegian Directorate of Fisheries (fiskeridir.no).

lousing agents are of special concern both among scientists (Langford et al., 2014) and fishermen (Bjørkan and Eilertsen, 2020). Recently, there has been an increase in research on the effects of salmon aquaculture on shrimp stocks and wild marine fish like cod (Bøhn et al., 2024; Moe et al., 2019). Fish welfare has also become widely discussed, both with regard to the conditions for the farmed salmon itself, but also for cleaner fish (wrasses and lumpfish) that are used in large numbers in the net pens together with salmon as biological control of salmon lice (Garcia de Leaniz et al., 2022).

Environmental sustainability concerns have been a major factor shaping aquaculture governance in Norway (Hersoug, 2015). This has included introducing special "green" licences and "R&D licences" to develop and implement technologies and practices to reduce environmental impacts and area conflicts. The licensing process has also been used to address a number of other concerns through the years, including regional development, fish diseases and ownership structure (Hersoug et al., 2019) (Hersoug et al., 2019). Finally, a traffic light system was introduced, regulating growth based on environmental performance of salmon farms (Hersoug et al., 2021).

2.3. Social acceptance of the aquaculture industry in Norway

Although the Norwegian aquaculture industry historically has had broad support by society (Chu et al., 2010), the social acceptance has become more debated in recent years. It has been argued that the industry lacks the social legitimacy to achieve further growth (Carson and Rønningen, 2016). Environmental externalities are central in this debate and are strongly linked to the level of acceptance (Hynes et al., 2018). As the concentration of farms increased together with production volume, the pressure on the environment has intensified, especially regarding wild Atlantic salmon. The number of wild salmon returning to spawn in the rivers in Norway was lower in 2021 than ever before, based on studies and time-series going back to 1980 (VRL, 2022). The causes of this are many and not fully understood, but salmon farming is seen as a major cause and continued threat. Fishing of wild salmon has been reduced both in rivers and at sea to counter the decline, and this affects local recreational fishers and tourism businesses related to salmon fishing. Negative attitudes to aquaculture growth reflect in part these concerns (Bailey and Eggereide, 2020).

As studies at the local level demonstrated, based on experiences in their daily operations, commercial cod fishers claimed to be affected (Bjørkan and Eilertsen, 2020), but scientific knowledge about the impact salmon farming have on marine species is still inconclusive (Barrett et al., 2018; Skjæraasen et al., 2021). The same local studies found that other stakeholders hold a positive attitude towards aquaculture and are satisfied with the contribution of the aquaculture industry to local communities in terms of tax income, ripple effects, employment and increasing activity and attractiveness of municipalities (Bjørkan and Eilertsen, 2020). Employment was found to be a significant predictor of attitudes to aquaculture at the national scale in Norway (Krøvel et al., 2019). Aanesen et al. (2018) estimated a positive WTP for aquaculture expansion in North-Norway and new jobs from it. Krøvel et al. (2019) found that living in proximity to fish farms does not make people more critical to aquaculture.

Coastal area use is another reason for opposition. The aquaculture industry is a major actor in the "battle for space" (Hersoug, 2013) along the Norwegian coast, where ocean space has become a scarce resource (Sandersen and Kvalvik, 2015). As the area occupied physically and visually by aquaculture has alternative use for recreation, fishing and sea transport, as well as nature conservation, the presence and growth of the aquaculture sector affects the interests of various stakeholder groups, and therefore their acceptance of aquaculture.

The ethical aspects of fish farming are also shaping attitudes to the Norwegian aquaculture industry. Grimsrud et al. (2013) showed that households are willing to pay for increased fish welfare. The high density of salmon in cages, the effect of treatments on stress and mortality and disease control are seen as problematic aspects of salmon farming. The discussions intensified due to the increase in the use of cleaner fish at salmon farms to combat sea lice. A recent report by the Food Safety Authority concluded that the conditions for the cleaner fish are often unsatisfactory thus leading to their high mortality (Mattilsynet, 2019). Moreover, the present practice where all cleaner fish are destroyed after use is deemed unsustainable.

The role of information and knowledge in forming attitudes to aquaculture have received much attention in the research in Norway. The situation described by Flaherty et al. (2019) in the study of attitudes to aquaculture in Canada, where "the public … finds itself caught within a fog of competing politicized agendas, contested science and misinformation" is similar to the Norwegian debate around aquaculture. Mass media play a key role in this respect, since their choice and framing of information creates certain images of the aquaculture industry, which in Norway is mostly negative (Olsen and Osmundsen, 2017) and conflict-framed (Tiller et al., 2012). The salmon farming industry also has information and communication strategies and measures to try to increase their legitimacy and social acceptance (Vormedal and Skjærseth, 2020). Media plays and important role in forming attitudes to aquaculture for several reasons. Cultivation of living aquatic organisms is a complex and knowledge-intensive activity. Thus, the role of science and communication of scientific information is crucial for public understanding of the environmental and health effects of farming and the product itself. Moreover, the large number and variety of stakeholders as well as political pressure makes the information exchange sensitive to manipulation and bias.

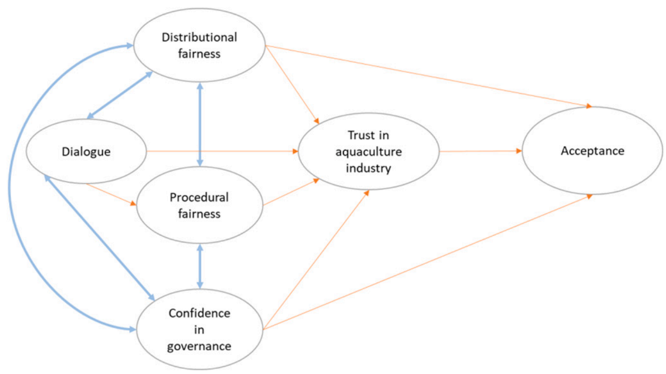
The literature on social acceptance of aquaculture in Norway suggests that factors of acceptance are mostly similar to aquaculture in other countries, however, the magnitude of effects on acceptance may differ. For example, while in Norway environmental impacts seem to be a major factor of acceptance, it was not significant in New Zealand (Sinner et al., 2020). This means that in different contexts the same factor may give very different impacts on the social acceptance, even for cases involving the same industry. For instance, the production form and scale of aquaculture differs between areas, where more intensive, high-trophic aquaculture causes stronger environmental concerns than small-scale or low-trophic farming. However, the difference may also be explained by the study design and methods, such as different formulation of survey questions and data collection.

3. Methods

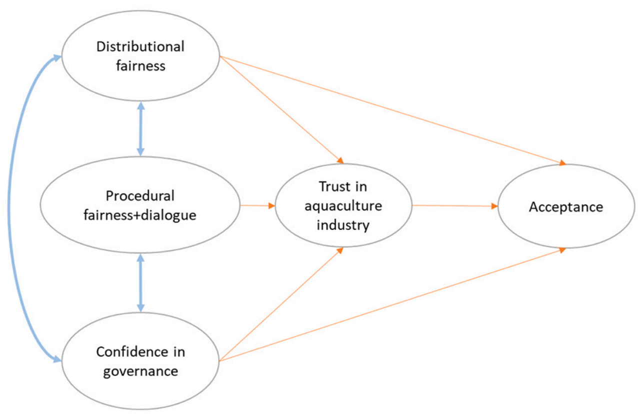
3.1. Trust models

We adapt a trust model framework and associated SEM method for modelling and measuring SLO, as has been developed in the literature on the social acceptance of mining (Mercer-Mapstone et al., 2018; Moffat and Zhang, 2014; Zhang et al., 2015). This strand of the SLO literature addresses the ambiguity of the concept and proposes a theoretical model and a related statistical method for quantifying the influence of different factors on social acceptance based on survey data.

The level of SLO in the trust models is defined as an unobserved (latent) variable termed *acceptance*, which is predicted by *trust* established between the industry, governing system and stakeholders locally. *Trust*, in turn, mediates the effect of other latent constructs. In addition to the mediated effect through *trust*, these latent constructs can have a direct effect on *acceptance* (Fig. 2). Among the common latent constructs influencing *trust* in different model specifications, are *procedural fairness* and *confidence in governance*. In some studies, *distributional fairness* is also present (Moffat and Zhang, 2014; Zhang et al., 2015).) Moffat and Zhang (2014) and Mercer-Mapstone et al. (2018) added constructs such as *dialogue*, *contact quantity, contact quality* and *relationships* as well. However, the definitions of these constructs represented by specific survey questions overlap with each other and with *procedural fairness* definition. To test the applicability of trust models to SLO for aquaculture



a: Model 1



b: Model 2

Fig. 2. Structural regression for SLO in aquaculture with Dialogue as a separate construct (a: Model 1) and structural regression for with Dialogue indicators included in Procedural fairness construct (b: Model 2). Indicators and variances are omitted from the figure.

industry, we need to aggregate the existing variations of the models in a way that captures common constructs and other specific constructs without much overlap. To this end, we consider two possible structures: one similar to Zhang et al. (2015) but including *dialogue* (*contact/relationships*) as a separate construct (Fig. 2a) and a model where measures of *dialogue* (*contact/relationships*) are included as indicators of *procedural fairness* (Fig. 2b).

In the resulting two models*, distributional fairness* refers to the expectation of receiving a fair share of benefits generated by the industry. It is a concept similar to benefit sharing in the field of social performance (Söderholm and Svahn, 2015). *Procedural fairness* refers to the stakeholders' perception of being included in the company's decision-making. *Confidence in governance* refers to the public''s perception of to what degree the governing system regulates the industry in the best interest of society. *Dialogue (contact/relationships)* is defined similar to Mercer-Mapstone et al. (2018) as a two-way exchange between community and industry, based on mutual respect and understanding, where all actors involved are able to share their opinions and listen to each other. This definition implies that the stakeholders are included in the decision-making, thus the construct is merged with *procedural fairness* in Model 2.

The statistical method typically used to test and quantify the relationships between the latent constructs in such models is *structural regression* (SR) which is a type of SEM (a classification of SEMs can be found in Lin, 2021). SEM is a term incorporating a wide variety of models with special cases including factor analysis, multivariate linear regression and path analysis (Oberski, 2014). Structural regressions, as a type of SEM, model relationships between unobserved, abstract constructs (latent variables). Some examples of latent variables in the social science and economics are intelligence, satisfaction, prosperity, social-economics status, and approval. The measurements of these variables are obtained through a set of observed indicators or items, often in a survey (Tarka, 2018). Latent variables are usually assumed to be continuous (Kline, 2023).

SEM are traditionally applied for theory testing, where research is concerned with the identification of causal mechanisms underlying a phenomenon rather than prediction of the outcome. The ability of SEM to reliably encompass many variables and relationships in a single linear model explains their wide application in social sciences studying complex and often abstract social concepts and processes (Tarka, 2018).

Fig. 3 illustrates the main principles of a structural regression. For detailed treatment of the SEM theory and application we refer to e.g., Bagozzi and Yi (2012), Kline (2023) and Tarka (2018).

The circles represent latent variables – theoretical constructs (e.g., *trust*) that cannot be directly measured, but are considered a function of some observed indicators (items) plus error. Indicators are depicted as squares and the loadings as arrows pointing towards indicators, meaning that the latent variable is predicted by these indicators. Regression path is represented as an arrow in the hypothesised direction of relationships. Here, variable A explains variation in B. Higher-order models where endogenous latent variable predicts another latent variable are possible to estimate with a sufficient sample size. Structural regressions modelling SLO as a function of trust are higher-order models.

The central element of SEM is comparing the covariance matrix of the data with a covariance matrix that is reproduced from the theoretical model being tested by the researcher (Gana and Broc, 2019). The model is accepted if the model-implied covariance matrix is equal to the observed matrix.

3.2. Data and models estimation

To estimate the models 1 and 2 (Fig. 2) we obtain measures for factor indicators (items) in a survey. The survey took place in 2019 in two Norwegian counties, Troms and Hordaland, as part of a larger on-line national survey (Olsen et al., 2023). The data collection procedure and the data set are available in Olsen et al. (2024). Participants were recruited by a survey company in Norway, using e-mail invitations. A random sampling was applied, where all members of the panel over 18 years old had equal chance to be invited. A degree of self-selection may present, as people interested in aquaculture issues and environment are expected to have higher response rate. However, people interested in aquaculture do not necessarily share the same views on it. In total, 364 respondents participated in the survey (177 in Troms and 187 in Hordaland, while population of the counties in 2019 over 18 years old was 134,000 and 411,000 respectively). Sample geographical distribution corresponded to the population in the studied counties but was slightly skewed with respect to gender (women were underrepresented). Age distribution in the sample was also slightly different from the population.

The questionnaire consisted of general demographic questions and questions measuring subjective perceptions and attitudes to the aquaculture development in the counties. Following common practice in the SLO literature, we applied a 5-level scale to measure the strength of attitudes and perceptions (Table 1). The answers provided measures of factor indicators (items) in the model.

Acceptance was measured by three items. The wording we use in the questions related to *acceptance* is slightly different from that in previous literature (Zhang et al., 2015) that used the words "tolerate" and "approve" as indicators. This is explained by the difference in context. Since one of the main controversies in aquaculture development in Norway is related to its further growth, and because the industry is one defining the image of the country as major seafood producer, we suggest

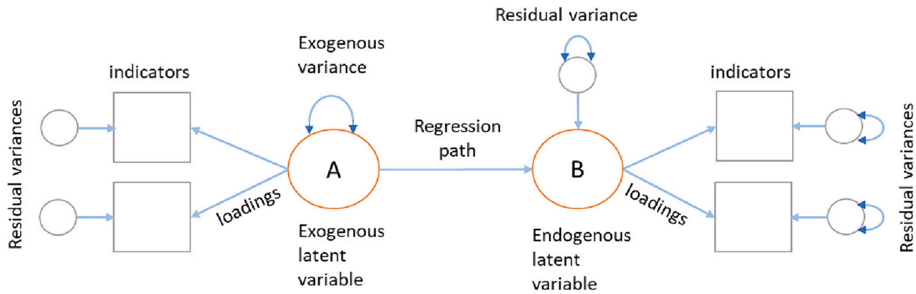


Fig. 3. Elements in a structural regression model (adapted from Kline 2005 and Lin, 2021).

that to want more aquaculture and feeling proud of it are more efficient indicators in this case.

Trust in aquaculture industry was measured by 4 questions adapted from Zhang et al. (2015) and Mercer-Mapstone et al. (2018). Although environmental sustainability was not explicitly used as indicators in the trust models before, we believe it is a defining indicator of trust in the aquaculture industry in Norway, based on our reading of the literature and knowledge of the public debate about this in Norway. Perception of the environmental effects of aquaculture in this respect reflects whether the industry does "what is right" (Moffat and Zhang, 2014).

Distributional fairness was measured by four questions adapted from Zhang et al. (2015) and extended to emphasize local economic benefits.

Procedural fairness was measured by four questions. The first two questions are adapted from Zhang et al. (2015) with an additional question emphasizing industries' own initiative. The last question is added to indicate whether the participation of community in the management of aquaculture is supported by fair access to information.

Confidence in governance was measured by two items. Although other authors defined *confidence in governance* as the belief in authorities as a guarantor of industries' accountability (Zhang et al., 2015), here we focus on other related aspect of the construct. While the ability of the Norwegian governing system to hold any industry accountable for its actions is seldom a matter of concern, political priorities are sometimes questioned. In the case of aquaculture, potential conflict of interest where authorities are seemingly supportive to aquaculture despite negative externalities, has been widely debated. Thus, we re-formulate the questions related to confidence in governance in a way that reflect this controversy.

Dialogue was measured by three questions formulated to capture the *quantity* and *quality* dimensions in line with Moffat and Zhang (2014). In addition, we measure the industry's availability for contact, in line with the definition of dialogue by Mercer-Mapstone et al. (2018).

The two models include a larger number of indicators (items) per factor than previous trust models. There are two reasons for that. First, we intended to include more aspects of the latent constructs. Second, we wanted to increase the stability of estimates. However, we could have maximum 4 indicators per factor due to the sample size limitations, where we aimed for a ratio between the number of observations and the number of parameters to be estimated between 3:1 and 10:1, that has been a common practice in social research (Bagozzi and Yi, 2012).

3.3. Alternative model (Model 3)

The dataset obtained from the survey was used to estimate models 1 and 2 (Fig. 2) to see how well the conceptual framework of trust models fits to the Norwegian aquaculture case. To assess their usefulness for aquaculture, trust models should be compared with an alternative, baseline model. If the trust models fit the data better than the alternative model, then trust models are superior, even if they do not demonstrate excellent fit. To build the alternative model we choose indicators that can be used as explanatory variables alone instead of being indicators for a latent variable (Fig. 4).

The observed indicators included in the alternative model are as indicated in Table 1. The choice of variables is based on the findings of previous literature on social acceptance of aquaculture in Norway as reviewed above. In addition to perception and attitude variables, we model the effect of demographic characteristics on acceptance. The demographic variables that have been studied in the context of aquaculture acceptance are (d-variables, Fig. 4): age, gender (2 levels), living in an aquaculture municipality (binary variable), income (6 levels), education (4 levels), interest in environmental issues (on 1 to 5 scale), knowledge about the aquaculture industry (self-evaluated on 1 to 5 scale) and frequency of salmon consumption (9 levels, origin of fish is not specified).

While leaving the *acceptance* part of the model unchanged, we modify the left part so that all variables explain *acceptance* directly, without mediator and all are observed variables. Within the SEM framework, the exogenous variables are still treated as latent variables, but each have only a single indicator (item). The difference of this structure from multivariate regression is that response variable is latent.

The models are estimated using "lavaan" package (Rosseel, 2012) in R Statistical Software (v4.2.2; R Core Team, 2022). Two-step procedure is applied. First, a confirmatory factor analysis (CFA) is performed to assess the measurement model. Factor loadings and error variances were estimated for each latent construct (see Appendix). Then the regression paths between exogenous and endogenous variables are estimated. Case-wise maximum likelihood estimation allows to use incomplete observations. Considering relatively small sample size and the number of parameters in the models, we estimated the data without application of sampling weights.

Goodness of fit assessment is done based on Hooper et al. (2008). CFI (Comparative Fit Index) has values between 0 and 1, and values >0.90, conservatively >0.95 indicate a good fit. TLI (Tucker-Lewis index) values >0.95 is considered to indicate a good fit. For RMSEA (Root mean square error of approximation), values around 0.06–0.07 indicate a good fit.

4. Results

4.1. Data summary

Fig. 5 summarizes the distributions of answer values to the questions related to SLO factors as indicated in Table 1. Fig. 5a is based on the full sample, while Fig. 5b represents answers from respondents in aquaculture municipalities (having salmon farms at sea or having the main office for large salmon companies). Unweighted data are used in both cases. Visually, the two figures are quite similar. About a third of answers are at value 3, which means that respondents give a neutral judgement. Questions about acceptance of aquaculture industry (Acceptance 1), meeting the authorities' expectations (Trust 2) and quality of contact with the industry (Dialogue 2) are items that received the most positive responses. Question on distribution of benefits locally and nationally (Distributional fairness 1, 2), willingness of the industry to listen to local representatives, change practices and take initiative to

Table 1
Survey question defining the items of SLO factors in models 1 and 2, and the alternative model 3.

Factor	Items	Included in the Model 3
Acceptance	1. On a scale from 1 to 5, to what extent do you **accept the aquaculture industry in Norway**?	
	2. On a scale from 1 to 5, to what extent do you **wish more of** the aquaculture industry in Norway?	
	3. On a scale from 1 to 5, to what extent do you **feel proud of** the aquaculture industry in Norway?	
Trust	1. On the scale 1 to 5, to what extent do you believe that the industry acts according to **society's expectations**?	included
	2. On the scale 1 to 5, to what extent do you believe that the industry acts according to the **authorities' expectations**?	included
	3. On the scale 1 to 5 to what degree do you **think of the industry as trustworthy**?	included
	4. On the scale 1 to 5 to what degree do you think of the industry as **environmentally sustainable**?	
Distributional fairness	1. Generally speaking, to what extent do you think the **benefits generated by aquaculture industry are fairly distributed locally**?	included
	2. Generally speaking, to what extent do you think the benefits generated by aquaculture industry are **fairly distributed nationally**?	
	3. On the scale 1 to 5, to what extent do **aquaculture producers in your municipality contribute to the local community development**?	
	4. On the scale 1 to 5, to what extent the presence of **aquaculture is economically important for your local community**?	
Procedural fairness	1. On the scale 1 to 5, to what extent do you experience that **salmon aquaculture industry locally listens to the opinions of the community**?	included
	2. On the scale 1 to 5, to what extent do you experience that salmon **aquaculture industry locally is willing to change practices according to opinions of the community?**	
	3. On the scale 1 to 5, to what extent do you experience that salmon **aquaculture industry locally take initiative to meet with local stakeholders**?	
	4. On the scale 1 to 5, **how accessible do you think information about the aquaculture industry is**?	
Confidence in governance	1. On the scale 1 to 5, to what extent do you **believe that Norwegian authorities regulate the aquaculture industry in society's best interest**?	included
	2. On the scale 1 to 5, how much do you **trust the Norwegian governance system**?	
Dialogue	1. On the scale 1 to 5, to what extent do you **experience that local aquaculture industry is available for dialogue with the community**?	
	2. On the scale 1 to 5, to what extent do you **experience contact with people from the industry as positive**?	
	3. On the scale 1 to 5, **how much formal and informal contact do you have with people who work in the aquaculture industry**?	

meetings (Procedural fairness 1,2,3) and quantity of contact (Dialogue 3) are evaluated negatively by most of the respondents.

4.2. Model estimation results

Reliability of the indicators as measures of latent variables is assessed by estimation of factor loadings and error variances in a CFA. The procedure was performed for all latent variables except for confidence in governance, since a two-items CFA model is unidentified (does not have necessary degrees of freedom). All factor loadings were statistically significant and error variances mostly low (see Appendix).

When estimating Model 1, we could not obtain reliable results due to estimated negative variance for the latent construct *procedural fairness*. There can be multiple reasons for this error, including outliers, missing values, convergence issues, empirical under-identification and sampling fluctuations (Kolenikov and Bollen, 2012). Formal testing possibilities is limited for some of the potential causes, however, considering that the negative variance is associated with a single variable, it may suggest structural misspecification related to this variable.

In Model 2, *procedural fairness* was merged with the *dialogue* construct, and we could obtain reliable estimates. The measurement model demonstrated reasonable fit. CFI and TLI values were in the range of good fit (0.935 and 0.923 respectively) and RMSEA value 0.073 in the range of reasonable fit.

Table 2 summarizes structural regression coefficients. The coefficients are interpreted as in linear regression, but the scales are standardized. In addition, variance standardization (Std.lv) and completely standardized solution (Std.all) are presented. The latter is commonly used to evaluate the strength of the relationships, as they are scaled from −1 to 1, absolute values close to 0.8 indicating strong association. Because all regressions in Model 2 are only between latent variables, the coefficients are the same under the Std.lv and Std.all columns. Covariances between latent variables are given in Table 3.

Based on the coefficients in Table 2, we can accept the hypothesis of positive association for three of the six regressions. *Distributional fairness* is positively associated with *trust*, but the coefficient is smaller than for *confidence in governance,* which is a stronger predictor of *trust*. *Trust* and *acceptance* are strongly associated. Standardized coefficient exceeding 1 is a sign of strong multicollinearity (Jöreskog, 1993), which means that the *trust* construct may be redundant.

We fail to accept the hypothesis on the positive association between *procedural fairness* and *trust*. The influence of *distributional fairness* and *confidence in governance* on *acceptance* could not be confirmed either.

As seen from Table 3, a strong association is found between the latent constructs, especially between *procedural fairness* and *confidence in governance*. Overall, the results of Model 2 suggest that the structural relationships as described by the model do not fit well the observed data, which is not an uncommon result in social research.

Model 3 demonstrated a much better fit with CFI 0.968, TLI 0.948 and RMSEA 0.059. Structural regression coefficients are listed in Table 4:

Attitudinal and perception variables contributed more to the level of *acceptance* of aquaculture than individual characteristics (demographics, knowledge, and frequency of salmon consumption). Perception of environmental sustainability is the strongest predictor of *acceptance* in the sample. How trustworthy the industry is and whether it acts according to society's expectations and interests has also a strong influence on *acceptance*. The association between availability of information and *acceptance* is significant on 10% level and is negative. Most of the demographic variables were significant or close to significant at the 5% level, except for the level of education. Knowledge about aquaculture industry and frequency of salmon consumption are the strongest predictors of acceptance among individual characteristics. Interestingly, salmon consumption is negatively associated with acceptance. Younger people in the sample tend to be more positive towards aquaculture industry than older ones, and women are more negative

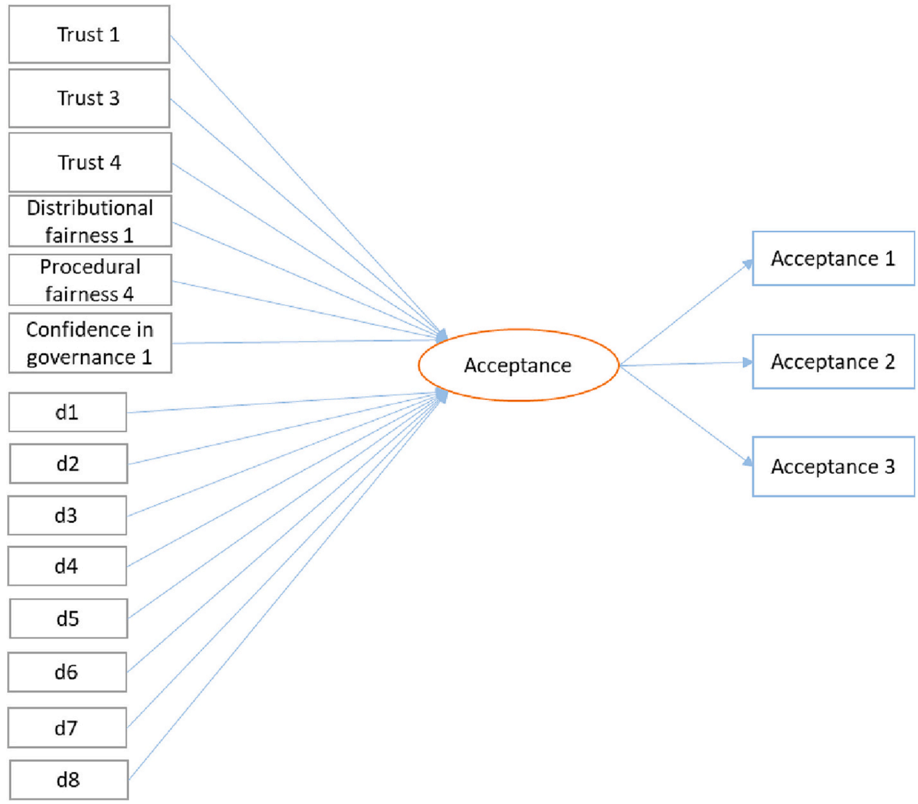


Fig. 4. Model 3 (Alternative model): acceptance of aquaculture industry predicted by attitudinal and demographic factors.

than men. The result is inconclusive on whether living in an aquaculture municipality has a significant effect on *acceptance* of the industry, but there is a sign of weak negative association. People having higher income has on average lower acceptance level, and so do people more interested in environmental issues, however for the latter, the hypothesis is accepted only on 10% confidence level.

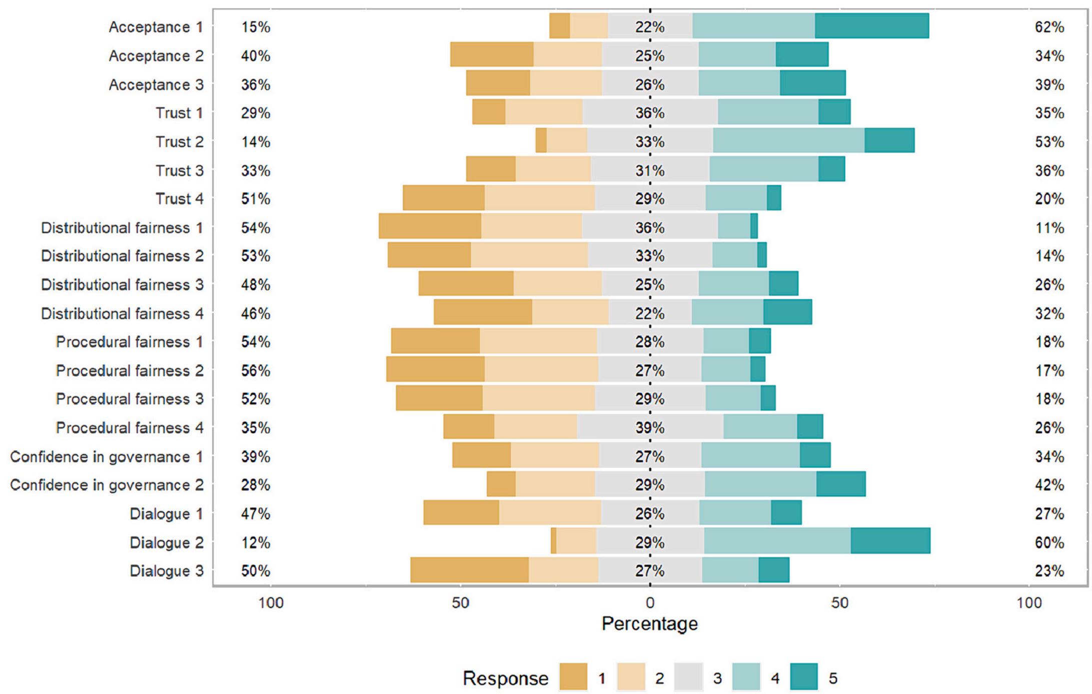
5. Discussion

Our main objective was to evaluate the potential of trust models of the SLO for studying social acceptance of the aquaculture industry in Norway. We also hoped to identify the most important factors affecting people's level of social acceptance for this. We estimated two variants of higher-level trust model with several latent constructs. The results suggest that these kinds of trust models, which were developed in the SLO literature for mining, do not suit well to the Norwegian aquaculture context. We also developed and estimated a simpler SLO model with only *acceptance* as a latent construct, and this had a better fit to the data of our case from two Norwegian counties.

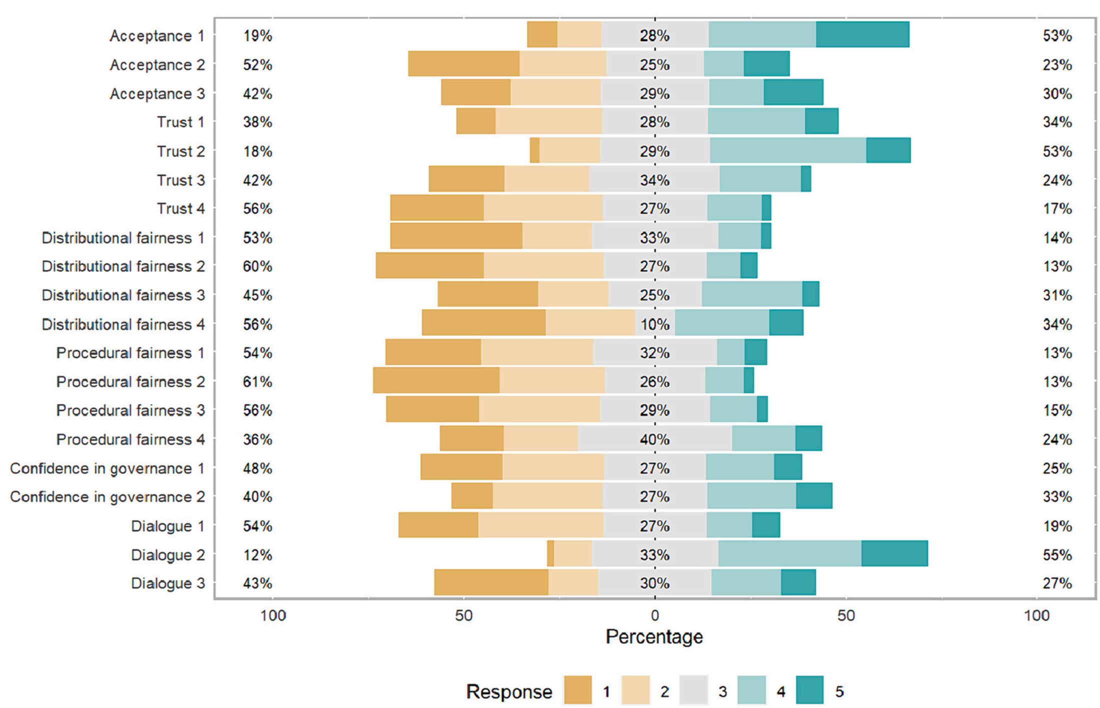
Although Model 2 was found to have reasonable fit overall with the data, several of the latent variables did not influence each other as found in trust models developed for mining. The fact that *procedural fairness* was not found to influence *trust* could be due to aquaculture in Norway being more dispersed and with smaller units than what is typical in mining. Thus, the dialogue and close relationship with the aquaculture industry could perhaps be expected to be less than with mining, and the responses to two of the *dialogue* items support this interpretation. It can also be due to relatively lower local economic importance than for mining. Aquaculture production takes place at about 1000 sites along the Norwegian coast, and the employment in the core aquaculture industry was 200 or more persons in only 30 out of 279 municipalities in 2022 (Nyrud et al., 2023). Similarly, 57 municipalities had 100 or more persons employed in aquaculture. On the other hand, many of these coastal Norwegian municipalities have rather small populations, meaning that 100 or 200 persons employed is of relatively large economic importance.

That Model 2 did not work well for explaining social acceptance of aquaculture in Norway is however most likely because important factors for this were not explicitly captured by the model. This regards especially the perception of environmental impacts of the industry. While we included it as an item for the factor of trust (believe that the industry is doing what is right), it was found to be a separate factor with direct and large influence on social acceptance in Model 3. Perhaps negative environmental impacts could be modelled as an item affecting distributional fairness in trust models. This could be an alternative specification for further research. The policy implication of the importance of environmental sustainability for the social acceptance of Norwegian aquaculture should however be clear. To improve the social acceptability of aquaculture, its environmental sustainability must be improved.

An alternative interpretation could however be that the perception of the environmental sustainability must be improved. It is not clear to what degree the population's perception of environmental sustainability for aquaculture is in line with the actual environmental situation or risk, but this would be crucial for acceptance. From the survey here, we see that the higher the self-assessed level of knowledge about the aquaculture industry is, the higher is the social acceptance. Yet, the better the availability of information about aquaculture is perceived to be, the lower is the social acceptance. Two future research needs are thus to investigate which aspects of environmental impacts of aquaculture that matter most for social acceptance, and whether people's perceptions of environmental sustainability for Norwegian aquaculture is in line with the actual situation. It could also be useful to see if this varies for different groups, like commercial or recreational fishers, or with geography, as this would make it easier to target policy measures and communication and make it more cost-effective. To determine the current environmental sustainability situation or risks can be challenging (Mikkelsen et al., 2021), but expert assessments (Grefsrud et al., 2023)



a)



b)

Fig. 5. Distribution of answer values: all observations (a) and aquaculture municipalities (b). The numbers in indicator label corresponds to the numbers in Table 1.

Table 2
Structural regression coefficients for Model 2.

	Estimate	Std.error	z-value	p(>|z|)	Std.lv	Std.all
Trust predicted by:						
Distributional fairness	0.431	0.113	3.802	0.000***	0.313	0.313
Procedural fairness	0.014	0.089	0.159	0.874	0.016	0.016
Confidence in governance	0.596	0.075	7.989	0.000***	0.701	0.701
Acceptance predicted by:						
Trust	1.265	0.332	3.815	0.000***	1.164	1.164
Distributional fairness	0.029	0.171	0.167	0.868	0.019	0.019
Confidence in governance	−0.296	0.219	−1.355	0.175	−0.321	−0.321

*$P \leq 0.05$ **$P \leq 0.01$ *** $P \leq 0.001$.

Table 3
Covariances between latent variables.

Covariances	Estimate	Std. Err	z-value	p(>|z|)	Std.lv	Std. all
Distributional fairness ~ Procedural fairness	0.582	0.068	8.579	0.000	0.847	0.847
Distributional fairness ~ Confidence in governance	0.516	0.069	7.484	0.000	0.703	0.703
Procedural fairness ~ Confidence in governance	0.885	0.085	10.457	0.000	0.793	0.793

and much monitoring data are available for Norwegian salmon farming, including down to the municipal level, e.g., through the public web service AquaInfo (Barentswatch, 2024).

Distributional fairness was found to be a relevant factor for trust and social acceptance in our analysis, using both Model 2 and Model 3. In the international literature this has been found to be important for social acceptance, not least related to mining (Söderholm and Svahn, 2015) and energy projects (e.g., World Bank; International Finance Corporation, 2019), often using the concept of benefit sharing. At the local and regional level in Norway this has also been a contentious issue for many years. Whether the introduction of the aquaculture resource rent tax and its mechanisms for redistribution of benefits from salmon farming will increase the social acceptance of the industry, and also municipalities' willingness to set aside more areas for aquaculture, are interesting questions for future research. A benchmark for the national level of social acceptance is now available (Olsen et al., 2023; Olsen et al., 2024).

6. Conclusion

The results of the study suggest that the trust models developed in SLO literature related to mining, forestry and other resource-extractive industries do not fit well to our data on perceptions and acceptance of the aquaculture industry in two regions in Norway. An alternative model of social acceptance however had good explanatory power. The results suggest that the most important factors for the local social acceptance of aquaculture in Norway are perceptions on the environmental sustainability of aquaculture, trust in the aquaculture industry, confidence in the authorities' governance of the industry, and fair distribution of benefits from the industry. To increase the social acceptance, the aquaculture industry and the authorities should prioritise working with these aspects.

Funding

This work was supported by the Norwegian Research Council's grant number 295114 (the SoLic project), and H2020 grant Agreement No. 869580 (the ArcticHubs project).

Author statement

The authors Katrine Eriksen and Eirik Mikkelsen ensure that all procedures in connection to this article were performed in compliance with relevant laws and institutional guidelines.

CRediT authorship contribution statement

Katrine Eriksen: Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Eirik Mikkelsen:** Conceptualization, Data curation, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing.

Table 4
Structural regression coefficients for Model 3.

	Estimate	Std.error	z-value	p(>|z|)	Std.lv	Std.all
Fair distribution of benefits locally (Distributional fairness 1)	0.136	0.037	3.684	0.000***	0.134	0.166
Industry acting according to society's expectations (Trust 1)	0.211	0.056	3.768	0.000***	0.208	0.223
Industry's trustworthiness (Trust 3)	0.191	0.052	3.695	0.000***	0.188	0.212
Aquaculture regulated to society's best interest (Confidence in governance 1)	0.147	0.047	3.169	0.002**	0.145	0.172
Aquaculture is environmentally sustainable (Trust 4)	0.232	0.051	4.505	0.000***	0.228	0.252
Availability of information (Procedural fairness 4)	−0.085	0.046	−1.852	0.064.	−0.083	−0.089
Age (d1)	−0.004	0.003	−1.469	0.014*	−0.004	−0.051
Gender (d2)	−0.200	0.069	−2.901	0.004**	−0.197	−0.097
Living in aquaculture municipality (d3)	−0.138	0.074	−1.860	0.063.	−0.136	−0.064
Income (d4)	−0.050	0.021	−2.405	0.016*	−0.049	−0.081
Education (d5)	0.037	0.041	0.890	0.373	0.036	0.030
Interest in environmental issues (d6)	−0.074	0.039	−1.907	0.056.	−0.073	−0.068
Knowledge about aquaculture industry (d7)	0.114	0.041	2.794	0.005**	0.112	0.111
Frequency of salmon consumption (d8)	−0.052	0.019	−2.693	0.007**	−0.052	−0.103

$P \leq 0.1$ *$P \leq 0.05$ **$P \leq 0.01$ ***$P \leq 0.001$.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Available online

Acknowledgement

We thank three reviewers for constructive comments.

Appendix A. Factor loadings and indicator error variances of latent variables

Indicators are as defined in Table 1. Std.lv is the variance standardized solution, Std.all is the completely standardized solution. CFA cannot be performed for latent variable *Confidence in governance* since it only includes 2 items.

Latent variable: Acceptance.

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	1.028	0.053	19.542	0.000	1.028	0.882
2	1.166	0.062	18.916	0.000	1.166	0.863
3	1.028	0.060	20.072	0.000	1.207	0.897

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.302	0.038	8.003	0.000	0.302	0.222
2	0.466	0.053	8.862	0.000	0.466	0.255
3	0.352	0.049	7.182	0.000	0.352	0.195

Latent variable: Trust.

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.971	0.050	19.511	0.000	0.971	0.892
2	0.677	0.049	13.747	0.000	0.677	0.702
3	0.948	0.053	17.783	0.000	0.948	0.840
4	0.944	0.053	17.730	0.000	0.944	0.838

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.241	0.034	7.087	0.000	0.241	0.203
2	0.473	0.042	11.234	0.000	0.473	0.508
3	0.375	0.041	9.154	0.000	0.375	0.294
4	0.377	0.041	9.203	0.000	0.377	0.297

Latent variable: Distributional fairness.

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.635	0.067	9.546	0.000	0.635	0.608
2	0.692	0.066	10.423	0.000	0.692	0.652
3	1.112	0.074	15.096	0.000	1.112	0.868
4	1.172	0.082	14.221	0.000	1.172	0.831

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.687	0.071	9.715	0.000	0.687	0.630
2	0.647	0.068	9.443	0.000	0.647	0.574
3	0.404	0.079	5.138	0.000	0.404	0.246
4	0.617	0.097	6.387	0.000	0.617	0.310

Latent variable: Procedural fairness (Model 1).

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	1.076	0.059	18.315	0.000	1.076	0.943
2	1.051	0.061	17.231	0.000	1.051	0.909
3	0.893	0.064	14.002	0.000	0.893	0.793
4	0.672	0.071	9.446	0.000	0.672	0.590

(*continued on next page*)

(*continued*)

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.144	0.035	4.120	0.000	0.144	0.111
2	0.232	0.038	6.117	0.000	0.232	0.174
3	0.471	0.051	9.286	0.000	0.471	0.371
4	0.848	0.083	10.198	0.000	0.848	0.652

Latent variable: Procedural fairness (Model 2).

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	1.036	0.067	15.857	0.000	1.063	0.928
2	1.023	0.071	14.396	0.000	1.023	0.876
3	0.922	0.071	13.047	0.000	0.922	0.824
4	0.701	0.083	8.481	0.000	0.701	0.600
Dialogue 1	1.167	0.074	15.736	0.000	1.167	0.924
Dialogue 2	0.608	0.066	9.281	0.000	0.608	0.645
Dialogue 3	0.273	0.071	3.826	0.000	0.273	0.294

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.183	0.030	6.025	0.000	0.183	0.140
2	0.316	0.042	7.551	0.000	0.316	0.232
3	0.402	0.049	8.180	0.000	0.402	0.321
4	0.874	0.097	8.968	0.000	0.874	0.640
Dialogue 1	0.235	0.038	6.208	0.000	0.235	0.147
Dialogue 2	0.519	0.058	8.893	0.000	0.519	0.584
Dialogue 3	0.789	0.086	9.200	0.000	0.789	0.914

Latent variable: Dialogue.

Indicator	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.763	0.113	6.747	0.000	0.763	0.609
2	0.854	0.103	8.270	0.000	0.854	0.899
3	0.398	0.074	5.354	0.000	0.398	0.436

Variances	Estimate	Std.Error	z-value	P(>|z|)	Std.lv	Std.all
1	0.989	0.157	6.307	0.000	0.989	0.630
2	0.174	0.153	1.134	0.257	0.174	0.193
3	0.676	0.075	8.964	0.000	0.676	0.810

References

Aanesen, M., Mikkelsen, E., 2020. Cost-benefit analysis of aquaculture expansion in Arctic Norway. Aquac. Econ. Manag. 24 (1), 20–42.

Aanesen, M., Falk-Andersson, J., Vondolia, G.K., Borch, T., Navrud, S., Tinch, D., 2018. Valuing coastal recreation and the visual intrusion from commercial activities in Arctic Norway. Ocean Coast. Manag. 153, 157–167.

Aanesen, M., Czajkowski, M., Lindhjem, H., Navrud, S., 2022. Trade-offs in the transition to a blue economy-mapping social acceptance of aquaculture expansion in Norway. Sci. Total Environ. 160199.

Alexander, K.A., 2022. A social license to operate for aquaculture: reflections from Tasmania. Aquaculture 550, 737875. https://doi.org/10.1016/j.aquaculture.2021.737875.

Anderson, J.L., Asche, F., Garlock, T., 2019. Economics of aquaculture policy and regulation. Ann. Rev. Resour. Econ. 11, 101–123.

Bacher, K., Gordoa, A., Mikkelsen, E., 2014. Stakeholders' perceptions of marine fish farming in Catalonia (Spain): a Q-methodology approach. Aquaculture 424, 78–85.

Bagozzi, R.P., Yi, Y., 2012. Specification, evaluation, and interpretation of structural equation models. J. Acad. Mark. Sci. 40, 8–34.

Bailey, J.L., Eggereide, S.S., 2020. Mapping actors and arguments in the Norwegian aquaculture debate. Mar. Policy 115, 103898. https://doi.org/10.1016/j.marpol.2020.103898.

Barentswatch, 2024. AkvaInfo. https://www.barentswatch.no/akvainfo/ visited 12 March 2024.

Barrett, L.T., Swearer, S.E., Harboe, T., Karlsen, Ø., Meier, S., Dempster, T., 2018. Limited evidence for differential reproductive fitness of wild Atlantic cod in areas of high and low salmon farming density. Aquac. Environ. Interact. 10, 369–383. https://www.int-res.com/abstracts/aei/v10/p369-383/.

Billing, S.-L., 2018. Using public comments to gauge social licence to operate for finfish aquaculture: lessons from Scotland. Ocean Coast. Manag. 165, 401–415.

Billing, S.-L., Rostan, J., Tett, P., Macleod, A., 2021. Is social license to operate relevant for seaweed cultivation in Europe? Aquaculture 534, 736203.

Bjørkan, M., Eilertsen, S.M., 2020. Local perceptions of aquaculture: a case study on legitimacy from northern Norway. Ocean Coast. Manag. 195, 105276.

Bøhn, T., Strøm, J.F., Sanchez-Jerez, P., Keeley, N.B., Johansen, T., Gjelland, K.Ø., Sandlund, N., Sæther, B.-S., Sætra, I., Olsen, E.M., Skjæraasen, J.E., Meier, S., van der Meeren, T., Bjørn, P.A., 2024. Ecological interactions between farmed Atlantic salmon and wild Atlantic cod populations in Norway: a review of risk sources and knowledge gaps. Rev. Aquac. https://doi.org/10.1111/raq.12899.

Boutilier, R.G., Thomson, I., 2011. Modelling and Measuring the Social License to Operate: Fruits of a Dialogue Between Theory and Practice. Online. https://www.socialicence.com/publications/Modelling%20and%20Measuring%20the%20SLO.pdf.

Boutilier, R.G., Black, L., Thomson, I., 2012. From metaphor to management tool: how the social license to operate can stabilise the socio-political environment for business. In: International Mine Management 2012 Proceedings, pp. 227–237.

Britsch, M.L., Leslie, H.M., Stoll, J.S., 2021. Diverse perspectives on aquaculture development in Maine. Mar. Policy 131, 104697.

Carson, S., Rønningen, K., 2016. 28. Norwegian salmon farming and the chase for social legitimacy. Food futu. 189.

Chico, J.R., Garcia, M.J., Sanchez, A.R.P., Sanchez, J.A.L., 2022. Socioeconomic acceptance of aquaculture measured through structural equations modeling. Are there discrepancies between men and women in Spain? Aquac. Econ. Manag. 26 (4), 439–461.

Chu, J., Anderson, J.L., Asche, F., Tudur, L., 2010. Stakeholders' perceptions of aquaculture and implications for its future: a comparison of the USA and Norway. Mar. Resour. Econ. 25 (1), 61–76.

Dalton, T.M., Jin, D., 2018. Attitudinal factors and personal characteristics influence support for shellfish aquaculture in Rhode Island (US) coastal waters. Environ. Manag. 61 (5), 848–859.

Duncan, E., Graham, R., McManus, P., 2018. 'No one has even seen… smelt… or sensed a social licence': animal geographies and social licence to operate. Geoforum 96, 318–327. https://doi.org/10.1016/j.geoforum.2018.08.020.

Fiskeridirektoratet, 2022. Nøkkeltall fra norsk havbruksnæring 2021 [In Norwegian: Key figures for Norwegian Aquaculture Industry 2021]. Report. Bergen. The Norwegian Fisheries Directorate. https://www.fiskeridir.no/Akvakultur/Tall-og-analyse/Statistiske-publikasjoner/Noekkeltall-for-norsk-havbruksnaering/_/attachment/download/1061b436-48ef-4487-bfb3-7daa1522a864:d0e72a4f979ac54fb7cb6ceed3493473b1bdbf5a/nokkeltall-havbruk-2021.pdf.

Flaherty, M., Reid, G., Chopin, T., Latham, E., 2019. Public attitudes towards marine aquaculture in Canada: insights from the Pacific and Atlantic coasts. Aquac. Int. 27 (1), 9–32.

Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., 2017. The major threats to Atlantic salmon in Norway. ICES J. Mar. Sci. 74 (6), 1496–1513.

Gana, K., Broc, G., 2019. Structural Equation Modeling with Lavaan. John Wiley & Sons.

Garcia de Leaniz, C., Gutierrez Rabadan, C., Barrento, S.I., Stringwell, R., Howes, P.N., Whittaker, B.A., Minett, J.F., Smith, R.G., Pooley, C.L., Overland, B.J., 2022. Addressing the welfare needs of farmed lumpfish: knowledge gaps, challenges and solutions. Rev. Aquac. 14 (1), 139–155.

Garlock, T., Asche, F., Anderson, J., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M.D., Tveterås, R., 2020. A global blue revolution: aquaculture growth across regions, species, and countries. Rev.Fish. Sci. & Aquacult. 28 (1), 107–116. https://doi.org/10.1080/23308249.2019.1678111.

Gehman, J., Lefsrud, L.M., Fast, S., 2017. Social license to operate: legitimacy by another name? Can. Public Adm. 60 (2), 293–317.

Grefsrud, G.E.S., Andersen, Lasse Berg, Grøsvik, Bjørn Einar, Karlsen, Ørjan, Kvamme, Bjørn Olav, Hansen, Pia Kupka, Husa, Vivian, Sandlund, Nina, Stien, L.H., Solberg, M.F. (Eds.), 2023. Risikorapport Norsk fiskeoppdrett 2023. Produksjonsdødelighet hos oppdrettsfisk og miljøeffekter av norsk fiskeoppdrett [In Norwegian: Risk Report Norwegian Fish Farming]. Institute for Marine Research, Bergen.

Grimsrud, K., Nielsen, H., Navrud, S., Olesen, I., 2013. Households' willingness-to-pay for improved fish welfare in breeding programs for farmed Atlantic salmon. Aquaculture 372, 19–27.

Gunningham, N., Kagan, R.A., Thornton, D., 2004. Social license and environmental protection: why businesses go beyond compliance. Law Soc. Inq. 29 (2), 307–341.

Hersoug, B., 2013. The battle for space: the position of Norwegian aquaculture in integrated coastal zone planning. Glob. Challen. Integrat. Coast. Zone Manag. 159–168.

Hersoug, B., 2015. The greening of Norwegian salmon production. Maritime Stud. 14 (1), 16. https://doi.org/10.1186/s40152-015-0034-9.

Hersoug, B., 2021. Why and how to regulate Norwegian salmon production? – the history of maximum allowable biomass (MAB). Aquaculture 545, 737144.

Hersoug, B., Mikkelsen, E., Karlsen, K.M., 2019. "Great expectations"–allocating licenses with special requirements in Norwegian salmon farming. Mar. Policy 100, 152–162.

Hersoug, B., Olsen, M.S., Gauteplass, A.Å., Osmundsen, T.C., Asche, F., 2021. Serving the industry or undermining the regulatory system? The use of special purpose licenses in Norwegian salmon aquaculture. Aquaculture 543, 736918. https://doi.org/10.1016/j.aquaculture.2021.736918.

Hitch, M., Barakos, G., 2021. Virtuous natural resource development: the evolution and adaptation of social licence in the mining sector. Extract. Ind. Soc. 8 (2), 100902 https://doi.org/10.1016/j.exis.2021.100902.

Hooper, D., Coughlan, J., Mullen, M.R., 2008. Structural equation modelling: guidelines for determining model fit. Electron. J. Bus. Res. Methods 6 (1), 53–60.

Hynes, S., Skoland, K., Ravagnan, E., Gjerstad, B., Krøvel, A.V., 2018. Public attitudes toward aquaculture: an Irish and Norwegian comparative study. Mar. Policy 96, 1–8.

Iversen, A., Asche, F., Buck, M., Henriksen, E., Stein, J., Svalestuen, S., 2020. The growth and decline of fisheries communities: explaining relative population growth at municipality level. Mar. Policy 112, 103776.

Jijelava, D., Vanclay, F., 2017. Legitimacy, credibility and trust as the key components of a social licence to operate: an analysis of BP's projects in Georgia. J. Clean. Prod. 140, 1077–1086.

Jijelava, D., Vanclay, F., 2018. How a large project was halted by the lack of a social Licence to operate: testing the applicability of the Thomson and Boutilier model. Environ. Impact Assess. Rev. 73, 31–40.

Jöreskog, K.G., 1993. Testing Structural Equation Models. In: Bollen, K.A., Long, J.S. (Eds.), Testing Structural Equation Models. Sage, Thousand Oaks, CA, pp. 294–316.

Jørgensen, F., Nordgård, K., 2023. Økende Kommunal Skepsis Til Oppdrett i Nord-Troms [in Norwegian: Increasing Municipal Scepticism to Aquaculture in Northern Troms]. Nordnorsk Debatt. https://www.nordnorskdebatt.no/okende-kommunal-skepsis-til-oppdrett-i-nord-troms/o/5-124-219834.

Kelly, R., Pecl, G.T., Fleming, A., 2017. Social licence in the marine sector: a review of understanding and application. Mar. Policy 81, 21–28.

Kline, R.B., 2023. Principles and Practice of Structural Equation Modeling. Guilford Publications.

Kolenikov, S., Bollen, K.A., 2012. Testing negative error variances: is a Heywood case a symptom of misspecification? Sociol. Methods Res. 41 (1), 124–167.

Kraly, P., Weitzman, J., Filgueira, R., 2022. Understanding factors influencing social acceptability: insights from media portrayal of salmon aquaculture in Atlantic Canada. Aquaculture 547, 737497.

Krøvel, A., Gjerstad, B., Skoland, K., Lindland, K., Hynes, S., Ravagnan, E., 2019. Exploring attitudes toward aquaculture in Norway–is there a difference between the Norwegian general public and local communities where the industry is established? Mar. Policy 108, 103648.

Langford, K.H., Øxnevad, S., Schøyen, M., Thomas, K.V., 2014. Do antiparasitic medicines used in aquaculture pose a risk to the Norwegian aquatic environment? Environ. Sci. Technol. 48 (14), 7774–7780.

Latapí Agudelo, M.A., Jóhannsdóttir, L., Davídsdóttir, B., 2019. A literature review of the history and evolution of corporate social responsibility. Int. J. Corp. Soc. Responsib. 4 (1), 1–23.

Leith, P., Ogier, E., Haward, M., 2014. Science and social license: defining environmental sustainability of Atlantic salmon aquaculture in South-Eastern Tasmania, Australia. Soc. Epistemol. 28 (3–4), 277–296.

Lin, J., 2021. Introduction to Structural Equation Modelling (SEM) in R with Lavaan. UCLA: Statistical Consulting Group. https://stats.oarc.ucla.edu/r/seminars/rsem/#s1a.

Mather, C., Fanning, L., 2019. Social licence and aquaculture: towards a research agenda. Mar. Policy 99, 275–282.

Mattilsynet, 2019. Sluttrapport: Nasjonalt tilsynskampanje 2018/2019: Velferd hos Rensefisk [In Norwegian: Final report: National Monitoring Campaign 2018/2019: Cleaner fish welfare]. https://www.mattilsynet.no/fisk_og_akvakultur/akvakultur/rensefisk/mattilsynet_sluttrapport_rensefiskkampanje_2018__2019.37769.

Meesters, M., Wostyn, P., Van Leeuwen, J., Behagel, J.H., Turnhout, E., 2021. The social Licence to operate and the legitimacy of resource extraction. Curr. Opin. Environ. Sustain. 49, 7–11.

Mercer-Mapstone, L., Rifkin, W., Louis, W.R., Moffat, K., 2018. Company-community dialogue builds relationships, fairness, and trust leading to social acceptance of Australian mining developments. J. Clean. Prod. 184, 671–677.

Mikkelsen, E., Myhre, M.S., Robertsen, R., Winther, U., 2021. Making a web-portal with aquaculture sustainability indicators for the general public. Front. Sustain. Food Syst. 5, 644314.

Misund, B., Olsen, M.S., Osmundsen, T.C., Tveterås, R., 2023. The political economy of salmon aquaculture: value sharing and societal support for aquaculture in Norway. Mar. Resour. Econ. 38 (4), 365–390.

Moe, S.J., Hjermann, D.Ø., Ravagnan, E., Bechmann, R.K., 2019. Effects of an aquaculture pesticide (diflubenzuron) on non-target shrimp populations: extrapolation from laboratory experiments to the risk of population decline. Ecol. Model. 413, 108833.

Moffat, K., Zhang, A., 2014. The paths to social licence to operate: an integrative model explaining community acceptance of mining. Res. Policy 39, 61–70.

Moffat, K., Lacey, J., Zhang, A., Leipold, S., 2016. The social licence to operate: a critical review. Forest.: An Int. J. Forest Res. 89 (5), 477–488. https://doi.org/10.1093/forestry/cpv044.

Nyrud, T., Iversen, A., Bendiksen, B.I., Robertsen, R., Steinsbø, S., 2023. Havbruksnæringens Ringvirkninger – Verdiskaping Og Sysselsetting 2022 [in Norwegian: The Ripple Effects of Aquaculture - Value Added and Employment]. Nofima report 32-2023.. Tromsø, Nofima.

Oberski, D., 2014. Lavaan. Survey: an R package for complex survey analysis of structural equation models. J. Stat. Softw. 57, 1–27.

Olsen, M.S., Osmundsen, T.C., 2017. Media framing of aquaculture. Mar. Policy 76, 19–27.

Olsen, M.S., Amundsen, V.S., Osmundsen, T.C., 2023. Exploring public perceptions and expectations of the salmon aquaculture industry in Norway: a social license to operate? Aquaculture 574, 739632. https://doi.org/10.1016/j.aquaculture.2023.739632.

Olsen, M.S., Mikkelsen, E., Alexander, K.A., Thorarinsdottir, R., Osmundsen, T.C., 2024. Survey data on public perceptions of salmon aquaculture industry in Norway, Tasmania, and Iceland. Data Brief 53, 110067. https://doi.org/10.1016/j.dib.2024.110067.

Owen, J.R., 2016. Social license and the fear of Mineras interruptus. Geoforum 77, 102–105.

R Core Team, 2022. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. URL. https://www.R-project.org/.

Rosseel, Y., 2012. Lavaan: an R package for structural equation modeling. J. Stat. Softw. 48, 1–36.

Sandersen, H.T., Kvalvik, I., 2015. Access to aquaculture sites: a wicked problem in Norwegian aquaculture development. Maritime Stud. 14 (1), 1–17.

Santiago, A.L., Demajorovic, J., Rossetto, D.E., Luke, H., 2021. Understanding the fundamentals of the social Licence to operate: its evolution, current state of development and future avenues for research. Res. Policy 70, 101941.

Sinner, J., Newton, M., Barclay, J., Baines, J., Farrelly, T., Edwards, P., Tipa, G., 2020. Measuring social licence: what and who determines public acceptability of aquaculture in New Zealand? Aquaculture 521, 734973.

Skjæraasen, J.E., Karlsen, Ø., Langangen, Ø., van der Meeren, T., Keeley, N.B., Myksvoll, M.S., Dahle, G., Moland, E., Nilsen, R., Elvik Schrøder, K.M., Bannister, R. J., Olsen, E.M., 2021. Impact of salmon farming on Atlantic cod spatio-temporal reproductive dynamics. Aquac. Environ. Interact. 13, 399–412. https://www.int-res.com/abstracts/aei/v13/p399-412/.

Söderholm, P., Svahn, N., 2015. Mining, regional development and benefit-sharing in developed countries. Res. Policy 45, 78–91. https://doi.org/10.1016/j.resourpol.2015.03.003.

Tarka, P., 2018. An overview of structural equation modeling: its beginnings, historical development, usefulness and controversies in the social sciences. Qual. Quant. 52, 313–354.

Thomson, I., Joyce, S., 2008. The Social Licence to Operate: What it Is and why Does it Seem So Difficult to Obtain? Prospectors and Developers Association of Canada Convention, Toronto, Ontario, Canada.

Tiller, R., Brekken, T., Bailey, J., 2012. Norwegian aquaculture expansion and integrated coastal zone management (ICZM): simmering conflicts and competing claims. Mar. Policy 36 (5), 1086–1095.

Vanclay, F., Hanna, P., 2019. Conceptualizing company response to community protest: principles to achieve a social license to operate. Land 8 (6), 101. https://www.mdpi.com/2073-445X/8/6/101.

Vormedal, I., Skjærseth, J.B., 2020. The good, the bad, or the ugly? Corporate strategies, size, and environmental regulation in the fish-farming industry. Business Politic. 22 (3), 510–538.

VRL, 2022. Status for norske laksebestander i 2022. [In Norwegian: Status for Norwegian Salmon Stocks in 2022]. Rapport fra Vitenskapelig råd for lakseforvaltning nr. 17.

Weitzman, J., Bailey, M., 2019. Communicating a risk-controversy: exploring the public discourse on net-pen aquaculture within the Canadian media. Aquaculture 507, 172–182.

Weitzman, J., Filgueira, R., Grant, J., 2022. Identifying key factors driving public opinion of salmon aquaculture. Mar. Policy 143, 105175.

Whitmore, E.H., Cutler, M.J., Thunberg, E.M., 2022. Social License to Operate in the Aquaculture Industry: A Community-Focused Framework. NOAA Technical Memorandum NMFS-NE-287.

World Bank; International Finance Corporation, 2019. Improving the Investment Climate for Renewable Energy: Through Benefit Sharing, Risk Management, and Local Community Engagement. © World Bank, Washington, DC. http://hdl.handle.net/10986/32748.

Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007. Social acceptance of renewable energy innovation: an introduction to the concept. Energy Policy 35 (5), 2683–2691.

Zhang, A., Moffat, K., Lacey, J., Wang, J., González, R., Uribe, K., Cui, L., Dai, Y., 2015. Understanding the social licence to operate of mining at the national scale: a comparative study of Australia, China and Chile. J. Clean. Prod. 108, 1063–1072.