

## Assessing Stakeholder Adaptive Capacity to Salmon Aquaculture in Norway

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### **Abstract**

This paper explores the socio-ecological effects of increased aquaculture/farmed fish production, around the island group of Frøya in Trøndelag, Norway, as a result of new licenses accorded to the industry. This is investigated from a stakeholder perspective by assessing the adaptive capacity of selected stakeholder groups through workshops combining Scenario Analysis, Systems Thinking and Bayesian Belief Network and by developing conceptual frameworks and structural diagrams that visualize the perceived effects of the industry on the given stakeholder system. This adaptive capacity is critical to explore before a de facto industry expansion. This is because context-specific adaptation policies and measures can reduce a given stakeholder group's vulnerability to negative consequences of industry expansion. Policy makers' a priori knowledge of these variables can lessen conflicts that may arise as a result of stakeholder discontent with top-down approaches to fisheries management and can also bring a legitimizing aspect to the political process leading to integrated coastal zone management (ICZM) in the region for affected stakeholder groups, possibly lessening simmering conflicts.

**Keywords:** Aquaculture, Stakeholders, Frøya, Norway, Bayesian Belief Networks, Scenarios, Coastal Management

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## 1. Introduction

The demand for farmed fish is strong and growing, a natural result of some research suggesting that 24–36% of wild fish stocks have collapsed worldwide and that 68–72% of global fish stocks are overexploited or collapsed (Worm, Barbier et al. 2006, Pauly 2007, Pauly 2008, FAO Fisheries and Aquaculture Department 2010). Capture fisheries have a strong impact on the ecosystem in which they operate and if the regular rate of capture continues, serious threats to global food security could be imminent given the decrease in wild fish reserves coupled with an increased global reliance on seafood for protein, largely driven by big emerging economies like India and China (Antunes Zappes, da Silva et al.). For decades, global fisheries policies have mitigated commercial fishing efforts in an attempt to reduce the amount of fishing pressure on wild stocks. Several solutions have been suggested to stop this downward trend of fish supply, including no-take Marine Protected Areas (MPAs) and moving from single species fisheries management to that of Ecosystem Based Fisheries Management (EBFM) (Ray 2011). There has been, however, increased attention on more direct adaptation possibilities in order to balance the increased demand for seafood and declining wild supply and the necessity to find more efficient means of food production to feed a growing population. During the last few decades, the primary method has been by aquaculture expansion (Abdallah and Sumaila 2007, van Vliet, Kok et al. 2010). Aquaculture already accounted for 46 percent of total global food fish supply in 2008 and is the fastest-growing animal-food-producing sector globally, even outpacing human population growth (FAO Fisheries and Aquaculture Department 2010). The per capita supply of animal protein from aquaculture has also increased, from 0.7 kg in 1970 to 7.8 kg in 2008, reflecting an average annual growth rate of 6.6 percent although this growth rate is beginning to slow. This mitigation path by policy makers is still to be considered a de facto realization that the attempts to mitigate capture fishing efforts to reduce pressure on wild stocks is failing (Kalikoski, Quevedo Neto et al. 2010).

Norway has seen enormous aquaculture growth since its inception and is currently the world leader in the production and export of farmed salmon. However, this was not always so, given that commercial fishing initially emphasized the use of the coastal zone. Given that the Norwegian coastline is 21 000 km long, and the sea area within the datum line is 90 000 km<sup>2</sup>, the country is a natural selection for the exploration of the adaptive capacity to an even higher increase in production. The topography and the hydrography of the country are much varied, altering between deep fjords and shallow sea, calm bays and areas of rapid currents. Temperature and salinity are stable and highly suitable for cold-water fish-farming, pollution and eutrophication are restricted to few areas, and water quality is good—all of which lays the ground work for both commercial fisheries and the large and increasingly diversified aquaculture industry (Ervik, J. et al. 2007). The Norwegian coast has naturally, given these benefits, always been influenced by human activity, and has historically been of great significance for the Norwegian society as a food source and a basis for development and prosperity. The living coastal areas offer great opportunities, but also present challenges unfortunately, especially with regards to the change from wild harvest of commercial fish species to the farming thereof. This was visualized with life on the Norwegian coast and its changes after the Second World War.

Rationalization and modernization of the commercial fishing industry and the fishing vessel-structure was characterized by conflicts and there was natural resistance against readjustments of these fisheries in coastal communities. Prior to this, the fishing industry had experienced great expansion and there were dramatic increases in production of different commercial species and highly developed fish-products, even resulting in the employment of women several places (Christensen 2013). Increased efficiency and better technology, however, made the fishing vessels more mobile and the total catch of some species soon neared collapse (e.g. Norwegian herring, smelt and coastal cod, Ibid), in line with the global experience at the time. In the coastal communities where the fisheries earlier had an important role, new and other businesses soon took over for this now declining industry, resulting in major conflict between the fisheries, the government and the politicians. The process resulted in severe deconstruction of the industry both at sea as well as on land, as measured by employment, but the fishing fleet in and of itself - and fishing processing industry - still kept increasing their fishing capacity. But life at the coast had nevertheless changed, as had the coastal communities and businesses. Oil and gas extraction, aquaculture and tourism became increasingly more important activities along the coast, resulting in both positive and negative reactions between the groups.

In light of this, the focus of this article is on the human dimensions of growth of the aquaculture industry, which currently represents 60% (US\$ 5.4 billion) of seafood exports, and where farmed salmon represents over 80% (850,000 tonnes) of annual aquaculture production (Fisheries-Norway 2010). There are many interests tied to the coastal zone such as conservation interests and recreation, to fishing, aquaculture, production of oil and gas, wind parks, transport and tourism. This necessitates good up-to-date coastal zone plans, especially since 276 out of 430 municipalities border directly on these coastal waters, and as many as 80% of the Norwegian population lives less than 10 km from the coast. As such, the following article has chosen to use as its case study the small island community of Frøya, located in the middle of Norway, about 2,5 hours from Trondheim. Here, the effects of aquaculture have been clearly visible, and, thus, adaptation and mitigation options in light of a tenfold increase in production are critical to investigate. This community has recently seen a positive population growth rate of around 3% and is highly dependent upon the aquaculture and subsidiary industries (Statistics Norway 2013), and the stakeholders interviewed in this paper generally expressed great content with the industry and its planned expansions and were very interested in providing their perceptions of future scenarios in this respect. In light of this, the paper first introduces the theories surrounding scenario developments in general, and the methodologies used in this project to develop quantitative scenarios based on the perceptions derived from four participatory stakeholder workshops during the end of 2012-beginning of 2013. This is followed by a general introduction to aquaculture and its role in society, both globally and Norway specific, after which a thorough contextual setting in the archipelago of Frøya is introduced. Finally, the respective stakeholder groups and their scenario development sessions are introduced, and the future political consequences of a ten-fold increase in aquaculture production are discussed.

## 2. Definitions, Theory and Methodology

In order for the reader to comprehend the arguments of this paper in greater depth, the following section introduces some definitions of repeated concepts throughout the paper. These are all limited descriptions that are explored further later in the article. The first of these concepts that is repeated throughout the article is that of a scenario. *Scenario* is a concept that is introduced in the following section, and that is often brought up in the article. It entails a series of hypothetical events that describe what could potentially happen within our environment in the future. In order to develop these scenarios scientifically and quantitatively, a range of methods is used in different disciplines. In our case, we chose to use the snowball method to find stakeholders that could participate in workshops and during this process develop scenarios for their group. The *snowball method* is a method that gives you a sample of respondents through referrals made among those that know others who have the same qualifications that the researcher looks for. For instance, in this case, we wanted to speak with local enthusiasts in Frøya. Although there are no organisations that assemble local enthusiasts, individuals who so self-identify may naturally interact with others of the same category (Biernacki and Waldorf 1981). We therefore contacted one person who had received an award for his local enthusiasm, and used the snowball method to find more candidates like him where he made the first calls and thereby started rolling the ball. Once we had found a group of candidates that were a representative sample, regardless of size of the group, we used the method of *Systems Thinking* to start the process towards developing the scenarios. This method is a group conceptualization tool that has as its aim to create a whole picture of phenomena, such as how a given group would be able to adapt to a ten-fold increase in aquaculture production, and create a model that represents this imagery and that catches the complexities inherent in a community. These models in turn can then be used either as a research tool for further exploration, or as a management tool in and of itself, to predict action of given groups for instance (Flood 2010, BeLue, Carmack et al. 2012). In our case, we used the software program *Vensim*<sup>1</sup> specifically designed for systems thinking, and developed by Ventana Inc., to explore the results of the systems thinking process and develop the actual model (Helfrich and Schade 2008, Lan, Lan et al. 2013). The variable with the most in- and output arrows from the systems thinking process is what is then usually the priority issue for the given group, like infrastructure was for the local enthusiasts, or preservation of commercial fisheries for that group. The group specific variables were then brought into the *Bayesian Belief Network (BBN) session*, where the process towards the development of the scenarios was continued. During the BBN session, as used in this project, the stakeholders were helped to develop structural diagrams, which can be used as tools for constructing coherent probabilistic representations of knowledge that is uncertain (Henrion 2013), such as that of stakeholders. The stakeholders, represented as experts of their groups, shared their perceptions of how a ten-fold increase in aquaculture production could affect their priority issue, such as income or cultural protection, to name a few. The *structural diagrams* are simple models that stakeholders develop during the BB sessions, which quantify probabilistic influences by showing how one variable affects another. These

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<sup>1</sup> Vensim.com

diagrams can then result in, through the software program *Netica*, developed by Norsys<sup>2</sup>, and MS excel (or equivalent), a set of *conditional probability tables (CPTs)*. These CPTs are the framework used in Bayesian network modeling to quantify the scenarios that the stakeholders have developed and require each stakeholder to ‘populate’ them by assigning a probability of outcome based on their perceptions about the future realization of each scenario. To account for multiple stakeholder perceptions, an *auxiliary expert variables* (labeled “stakeholder”) is included in the BBN. This auxiliary variable enables assessment at both group- and individual-level regarding the scenarios. These definitions will be often mentioned in the rest of the article, and are key concepts for the study of stakeholder perceptions to a future ten-fold increase in aquaculture production in the island community of Frøya in Trøndelag, Norway.

## 2.1 Aquaculture

Aquaculture, or fish farming, is the production of aquatic organisms such as fish, seaweeds, and mollusks, using tanks onshore and cages in coastal and fresh waters. The early 1900’s marked the beginning of aquaculture as an industrial system that relied on regional and some international trade. By the 1970’s the industry had expanded globally and has had exponential growth ever since, with a focus on high value species with a high export demand (FAO Fisheries and Aquaculture Department 2010). As it is practiced today, modern farming techniques resemble any other industrial system, and contribute to political, social and environmental challenges. These challenges generate a considerable amount of conflict between stakeholders who are competing over precious coastal zones. Aquaculture benefits from its similarity to agriculture in meeting customer demand through quality, reliability, and year-round production capacity. As demand for seafood increases worldwide, wild fish stocks have not been able to keep pace, allowing aquaculture an opportunity into the marketplace. In 2006, the global collapse of fisheries represented nearly one third of fished species, trending toward further collapse if sustainable fisheries management were not implemented (Worm, Barbier et al. 2006). Aquaculture also puts an enormous strain on wild fisheries, though, and it is believed that 31% of the worldwide catch of wild fish in 2005 went toward feeding fish in farms (Weible, Pattison et al. 2010). It is furthermore estimated that by 2030, 85 million tonnes (nearly 50%) of the global supply of seafood will come from aquaculture (FAO Fisheries and Aquaculture Department 2010, Marine Stewardship Council 2012), indicating an even higher strain on global wild fish for fish feed for carnivorous species like salmon (Rosamond L. Naylor, Rebecca J. Goldberg et al. 2000). The aquaculture industry also struggles with negative publicity such as, among others, diseases, parasites and escapes. Diseases such as infectious salmon anemia (ISA), parasites such as sea lice and mass escapes can have dire consequences for the eco-system within which the farms are located, and spillover effects to the human population as well (Costello 2009, Hansen and Onozaka 2011, Torrissen, Jones et al. 2013). Given this information, it is going to take a coordinated effort to ensure this industry grows in a sustainable way that prevents both negative social and environmental effects.

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<sup>2</sup> <http://www.norsys.com/netica.html>

Norway is a fishery nation with long traditions for hunting and fishing both on the high seas and near shore, and its expansion to aquaculture was natural given that the natural prerequisites for both commercial fisheries and aquaculture are fortunate in Norway where the country's long coastline includes deep fjords, islands and sheltered coves, stretching out more than 58,133 km (CIA 2011). As opposed to commercial fisheries, though, aquaculture along the coastline makes it possible to harvest seafood all year independent of the fisheries seasons. This industry has therefore become of great value and has created many jobs along the rural areas of the Norwegian coast, in line with the political priorities of the sitting government in Norway of keeping the lights on in the homes of these areas (Pedersen 2006). The aquaculture industry has also been critical in the development of spin-off industries and is an important contributor to the supply and processing industry as well. This is of crucial importance for the life in the coastal communities, and creates economic growth in both rural districts as well as larger cities. Norway is currently the world leader in the production and export of farmed salmon, and seafood is the largest industry in Norway after gas and oil. The aquaculture industry represents 60% (US\$ 5.4 billion) of seafood exports, and farmed salmon represents over 80% (850,000 tonnes) of annual aquaculture production (Fisheries-Norway 2010). In 2008, it was estimated that 5,000 jobs were directly related to the aquaculture industry, and 20,000 jobs indirectly (Ibid). The products from the industry currently represents the third most important export article from Norway (after oil 40,4 % and gas 23,4%; seafood is at 6,6%), and the export of farmed salmon and trout has even exceeded the export value of natural caught marine species. The value of Norwegian salmon exports in the first quarter of 2013 alone was 8,2 billion NOK (about USD 1.4 billion), with the main export markets being France, Poland, EU, Russia, Denmark, USA, Spain, Germany, Sweden, Great Britain and Japan (Purcell 2007, Statistics Norway 2013).

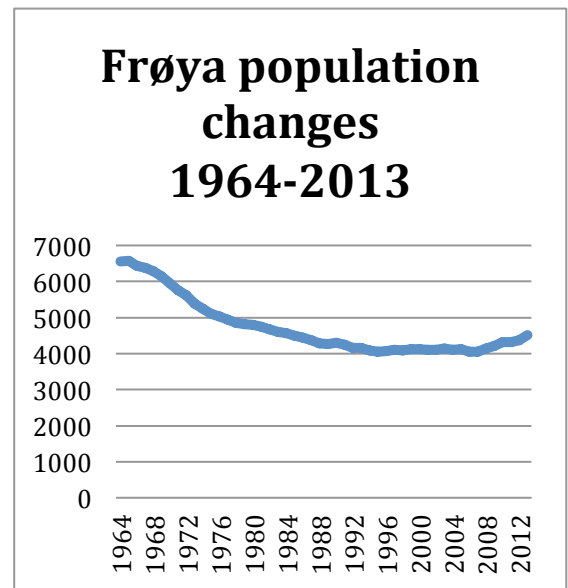
Since industrial scale aquaculture began in Norway, the industry has struggled with stakeholder contentment, though. One struggle has been the competition for coastal use at the exclusion of other uses such as tourism and open access, and another struggle has been the social and environmental impact (Tiller, Brekken et al. 2012, Tiller, Gentry et al. 2013). Outbreaks of diseases at salmon farms have also caused large scale environmental impacts, such as the spread of the parasite *Gyrodactylus* in 1975 that devastated wild salmon populations, the 1984 ISA outbreak that killed 80% of farmed salmon and permanently spread to wild populations, and the bio-accumulation of antibiotics and chemicals (FAO Fisheries and Aquaculture Department 2010, FAO Fisheries and Aquaculture Department 2012). One of the reasons for the stakeholder struggles also lies at a more cultural level, with the decline of the commercial fisher. In the commercial fisheries, though there still represent about 5400 fishing vessels employing a total of about 12 200 fishermen, export goods represented only 2, 6 billion tonnes of seafood, valued at 1 billion NOK, in 2013. This is a result of reconstruction, white fish filet plans closings and industry bankruptcy, and has led to widespread decrease in employment in the commercial fishing industry businesses the last 10 -12 years (Kim, Seo et al. 2012).

At the same time, the amount of migrant workers in the farmed fisheries industries has increased dramatically, especially after the entry in 2004 of 10 new states into the European Union. In many industries, the number of hired workers from Latvia, Estonia, Lithuania, Poland, Russia, Romania, and Bulgaria

has ranged from a few percent in 2001 to 18 % in 2009 and in some companies, up to 80% percent (Graham, Martin et al. 2003). Though this was likely not the intended path of the Soria Moria declaration of the sitting Norwegian government, where keeping the lights on in the homes along the rural coast line was one of the election promises (Regjeringen Stoltenberg II 2005), it has nevertheless had the desired positive effect, especially in small communities with great natural advantages when it comes for the farming of salmon, like Frøya, in Trøndelag, Norway.

In both Frøya and Hitra, the neighbouring archipelago, significant restructuring in both commercial fishing and agriculture caused a population loss of 38% from 1964-1995 (Van auken and Fredrik Rye 2011, Statistics Norway 2013). However, with the advent of aquaculture, this trend has been dramatically changed to a population change that has been positive since 2008, and was at 3.04% in 2013, with the current population being 4506 inhabitants (Statistics Norway 2013). The Norwegian success story of seafood production is in many ways also the success story of the island community. The first attempts at reproducing salmon found in the oceans was done in Frøya and Hitra in the early 1970`s. The first experiences of salmon farming with smolt from the wild salmon in the regional rivers were also done there, when the pioneers started hatching eggs and creating one of the first successes in Norwegian salmon farming history and a new era begun in Norwegian coastal industries (IMH, 2008). The salmon industry has since become an international business, and this coastal region of Trøndelag has played an important role and has had a leading position in the development of the aquaculture farming history in Norway. You may say that it was no coincidence that the salmon-adventure started in this region given that both geographical and climate issues are ideal for salmon farming here. Additionally, the pioneers' experience and knowledge obtained from the commercial fishing industry through the centuries, was of crucial importance for the success story of Frøya. These fishermen tried and they failed, and did it all over again. Their work has also contributed to a significant body of aquaculture expertise in the region, and as early as 1980, the Frøya High School offered a genuine education in aquaculture. Today, Frøya is ranked the 5th of the 10 most successful rural municipalities in Norway (Richardson, Bakun et al. 2009). This means that Frøya is one of the municipalities that has been successful both in terms of industrial development and in population growth.

The archipelago of Frøya has traces of human activity going all the way back to 11 to 12,000 years ago, and there have been several Stone Age discoveries such near the community center of Sistranda. Early ice-free coast and abundant supply of fish and marine animals were the reasons for the very early settlements, and the rich fisheries then provided a good basis for existence, and have at all times since. Frøya was even the most populated municipality on the Trøndelag Coast until the 1970s, after which it experienced its collapse until its recent rebirth. Today aquaculture is the largest value creator by far on the island



community. Frøya is one of the leading municipalities in both salmon farming (37 sites in seawater) and processing of aquaculture products. 14 of the 15 largest companies on Frøya in 2007 were either salmon farmers or other aquaculture related industries. Value added per capita is among the highest, and on top in Trøndelag. The municipality's largest business, the salmon farming- and processing company SalMar, completed and launched in 2011 an extensive construction and a huge expansion of their new salmon-processing plant located on Kverva, Frøya, which is Europe's largest salmon processing plant of its kind (Webb 2007).

This kind of increase in production also leads with it the need for more workers, which in the case of the salmon industry resulted in a need for foreign immigrants. In 2013 the region had around 500 migrant workers from around 40 different nations (Dunlap 2013). The SalMar ASA Company alone employs 660 persons, 400 specifically on the Innovamar-plant on Frøya, representing 25 different nationalities. In light of these challenges, the municipality of Frøya has put a lot of effort to preserve and facilitate for the working-migrants on the island. But Frøya is also facing a huge challenge when it comes to developing and managing a multi-cultural community. The municipal report (Frøya Kommune 2012) points out that there many examples of good individual efforts to create good relationships between nationalities, but that it lacks continuity. As the population in a few years may consist of nearly a thousand new residents as a result of labor migration, this can no longer be ignored or taken lightly, according to the report. These challenges are those that could seem most pressing in a future of a tenfold increase in aquaculture production, and was what expected to come up most often in the discussion with the stakeholder groups as a focus of needs for the future.

## 2.2 Scenario Analysis

Quantitative stakeholder-driven scenarios, created in a participatory workshop setting, are effective in assessing the effects of a ten-fold increase in aquaculture production in a limited area. These scenarios can be both positive and negative and are important tools for policy makers, especially when they are flexible and can be operated by the end user after its creation. The need for such scenarios arises due to the inability of the traditional single sector management to effectively address the cumulative impacts of multiple stressors, resulting in declining productivity of ocean ecosystems and escalating conflicts between user groups (Lester, McLeod et al. 2010, Lubchenco and Sutley 2010). Understanding stakeholders' perceptions of how potential changes in management will affect them is essential to both guide managers to identify and resolve areas of potential conflict before the fact and to assess how stakeholder perceptions compare to scientific analysis of impacts.

The founder of the Scenario method was Herman Kahn. The original intentions of the storylines in the scenarios, namely the different futures the *researcher* envisioned, were to be lively but realistic and attempt to draw attention to causal relationships between actual developments and the possible interventions policy makers or businesses could prepare for in the event of an actualization of a given scenario (Botterhuis, van der Duin et al. 2010). The use of the word 'scenario' is increasingly popularized in the social sciences, with great variability to the methods used to reach them. There is a great level of



scholarship that offer typologies, methodologies and theories about the use and interpretation of the term, as well, but the consensus appears to land on the agreement of scenarios being *hypothetical, causally coherent, internally consistent* and/or *descriptive* (Philip van Notten 2006), all of which are achieved by using participatory workshop method mixes of systems thinking and Bayesian Belief Networks.

The literature generally highlights, though, that scenarios are *not* predictions (Steven P Schnaars 1987, Hugues 2000, Kristóf 2006, Lena Börjeson, Mattias Höjer et al. 2006). This is in line with the Schrödingers Cat analogy, and admittance from the scholar that scenarios only can indicate *explorations* of the future. The cat analogy, from quantum physics and applied to scenarios, visualizes how one can never predict any one outcome with certainty; only a certain number of possible or plausible results within a range of predetermined levels of probability can ever be proposed. Furthermore, until the future takes place, neither proposed results are real. The Schrödinger Cat analogy is a thought experiment that has the participant imagine a confined space such as an enclosed room or a closed box and in this room there are two items – a cat and a vial of poison. If the poison container is broken by the cat, or in some other manner, the cat will die. Looking at the confined space from the outside we therefore state that the cat is either alive or dead. However, without an actual observation thereof, the paradox of Schrödinger Cat demonstrates that we actually do not know whether the cat is alive or dead. The cat is therefore *neither* dead *nor* alive, until otherwise proven (Gribbin 1984), just like the future is to a scenario building scholar (Tiller 2010). Forecasts and scenarios can be proposed and explored, but neither suggestion offered, whether based on linearity or history or expert opinion is correct until it is observed at a future time.

However, it is critical to employ both quantitative and qualitative research to get a full and nuanced picture of the ramifications of policy change. Some sectors typically focus on variables and relationships that are more clearly structured than others and therefore are more able to be predicted. For example, there are standardized algorithms used in the prediction of climate indicators (e.g. temperature, irradiance), physical processes (e.g. hydrodynamics) and biogeochemical rates (e.g. mortality, mineralisation, solubility). These mathematical-based models are often used for predictions and forecasting, such as in the area of meteorology (Gould 2011). However, *human interaction* is changing this in a range of areas; the human breakage of what has been named the natural rhythm is observable in the atmosphere currently, a scenario that was foreseen by natural scientists as early as 1910 (De Jouvenel 2000). The effect of human interference has also been experienced in fisheries and forestry (Ostrom 2009). How people perceive the interactions that they have with natural resources, as well as other stakeholders, has great influence on both their behavior and the nature of the conflict. In order to account for this, policy makers often look to identify trends, assess different possible or plausible futures, and evaluate the information to see what changes could be critical in the future. This envisioning of future landscapes is well within our grasp of comprehension, even if one can never accurately foresee exact events in a case where human and social variables are involved, given the complexities of free will and coincidences (Slaughter 1994, Botterhuis, van der Duin et al. 2010).

### 3. Methodology

The function of the scenarios is in many cases, and in the Frøya aquaculture expansion case specifically, to aid policy makers and business owners in their quest to evaluate and select strategies for the future by exploring all options and being prepared for possible conflict lines. A methodological approach that helps achieve this outcome is to involve stakeholders in developing future scenarios, or possible images of different futures, relative to their system. In the current project, we used the method of systems thinking to map mental models based on the stakeholder group analysis, providing a conceptualization of the system based on the given stakeholder group's beliefs. This process also aids in identifying important elements or variables within the system conceptualization that have influence over, or are influenced by, other variables within the same system. A benefit of using this approach is that it allows exploration of a complex system at the local scale (in this case, stakeholders in the community of Frøya, Norway) based on the expertise of the stakeholders themselves. This process utilizes the knowledge of the stakeholders to identify potential drivers and consequences of offshore aquaculture to their sector.

We started the group model building experience by presenting pertinent background information about the project, and encouraged the participants to imagine a future where there was a ten-fold increase in aquaculture, and reflect on how they felt this would affect them. We used this future scenario as a proxy for eutrophication, which is the focus of the CINTERA project<sup>3</sup>. This was done to make the imagery more relevant for the stakeholder, and to obtain more context related answers.

The 5 workshops, which ranged in size from 10 scientists, 9 students (future generation), 6 local enthusiasts, 6 foreign workers and 5 commercial fishermen, were conducted during the spring of 2013. The stakeholders were selected using the snowball method through their respective organization (the commercial fishermen), their teachers (we were allowed to lead a class for four hours), their supervisors (the foreign workers at the Aquaculture company), the main local enthusiast (he knew who would be the best representatives of this category), and through invitations to relevant research networks (the scientists). The quality of the results sampled from these groups far outweighed their relative small number, as is often the case in qualitative research studies where large samples can be ineffective and do not provide the detailed and contextual information wanted by the researcher. In a narrative analysis, which this project included, the researched judged 15 to be the upper limit of what would provide a holistic narrative where all participants were given ample opportunity to share. The sample size can be as small as one or two as well, if this participant has information that is of critical value for that given sector and advances the research towards a specific goal (Sandelowski 1995). The participants in this project were sought out because they were considered experts of their own sector, and good sources of information and perceptions about the future of the Frøya community with a ten-fold increase in aquaculture production.

In order to elicit information and scenarios, the stakeholders were first provided with contextual information regarding the project. This included being

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<sup>3</sup> CINTERA (A Cross-disciplinary Integrated Eco-systemic Eutrophication Research and Management Approach) is NFR project 21667. It started in July 2012 and will continue through June 2015.

briefed on the project aims and, from the literature, an overview of negative and positive issues related to aquaculture in their area or sector of concern, including visualizing possible aquaculture nets and pens and how these would be located in the water column (Impson 2011). The briefing was supported by projections concerning global seafood availability, the expansion of aquaculture and preliminary outcomes of research about eutrophication, focusing on the implications of aquaculture expansion on the vulnerabilities of different stakeholders in the sector which was of primary concern to them.

The system conceptualization process was initiated by presenting the participants with seven predetermined ‘drivers’, selected by the researchers before the workshop. These drivers were presented as variables and therefore included multiple states or settings (e.g. if the variable is ‘the color of a boat’ then potential states could be red/blue/green etc). The selection of these drivers was based on literature review and expert interviews. Here, drivers can influence other variables, but are typically not affected themselves, within the stakeholder’s sector and are therefore independent variables. The drivers presented to the workshop participants were:

- the quantity of farmed seafood released to the market;
- the space taken up by the aquaculture industry;
- the animal welfare of the farmed fish in their pens;
- the waste from the farmed seafood;
- traffic to and from the farm sites, both in water and on land;
- industry waste such as nets, buoys, and “normal” trash; and
- the design and construction of the nets in the area.

The participants were then asked to nominate additional variables (within the context of their sector) that they believed would be influenced, either directly or indirectly (via other variables), by the driver variables. Examples of this process might include themes such as whether the availability of fishing grounds would affect their income, or how aquaculture pens drifting off course due to weather would affect them. This exploration then led to identification of additional variables that represented possible management responses that could be used to mitigate any negative impacts of offshore aquaculture on this specific sector. The variables identified by the stakeholders through this process were recorded on a large white board using colored ‘post-it’ notes (example Figure 1). The workshop participants were then prompted by the researcher (workshop facilitator) to identify connections between these variables in the form of directional associations; for example, such connections could highlight that employment in the fisheries sector is affected by the area taken up by the Aquaculture industry, or if the amount of fish that an aquaculture venture released to the market directly affected the landing prices for a given wild fish stock from the capture industry.





The framework for developing the BBNs was presented to the workshop participants. As a group, they were first instructed to assign two (dichotomous) states to their priority issue, “Infrastructure” in the case of the local enthusiasts for instance, as a means of discretising this variable. The workshop facilitator guided the participants on the selection of these states including informing them that they had to be discrete states (as opposed to continuous), mutually exclusive (only one state can be true at any given time) and that the states be exhaustive (all potential outcomes are covered by the states). These rules are fundamental tenets of BBN development (Marcot, Steventon et al. 2006) although the selection of dichotomous states entails that these are often broad qualitative descriptions. Conversely, restriction to dichotomous states enhances the tractability of the associated conditional probability tables (described elsewhere), which can otherwise be a serious impediment in BBNs that rely heavily on expert elicitation to parameterize them (Kjaerulff and Madsen 2008).

Further guidance on the selection of the dichotomous states was provided in that they should reflect a desirable and undesirable state respectively. Often, the stakeholders select states of “high” and “low” or “good” and “bad” for the variable. In the example of “Infrastructure development”, the states chosen were “realistic” and “not realistic” with reference to a ten-fold increase in production. In the next step of the BBN development process, the stakeholders were asked to identify three primary variables that would directly influence their capacity to manage their priority issue at their desirable state (i.e. Infrastructure developments = “realistic”). The priority issue and the three primary variables along with their respective states were then put up on colored post-it notes on the board, so that the stakeholders at all times could see what they were deciding upon in unison. This was helpful when the second level of causality (secondary variables) in the developing BBN diagram was created. This process required that they assign up to three variables for each of the three primary variables, based on the concept that these secondary variables directly influenced the primary variables. The participants assigned dichotomous states to each of the secondary variables in a similar manner as for the priority issue and the primary level variables (figure 3).



Table 1 – An example of a populated conditional probability table from the Foreign Workers. Stakeholders provide the %s by going through the scenarios and responding to the question ”What is the percentage probability (0-100%) that Your Language Learning will be so good, it will make you ‘FLUENT’ in Norwegian for the following 8 scenarios?”

Local Community speaking Norwegian with you	Course Offerings	Teaching Quality and Method	Probability in % of your language learning being so good, you will be able to learn fluent Norwegian from 0-100.
Actively Interested	Flexible	Adaptable at the individual level	100%
Actively Interested	Flexible	NOT Adaptable at the individual level	60%
Actively Interested	NOTE Flexible	Adaptable at the individual level	80%
Actively Interested	NOTE Flexible	NOT Adaptable at the individual level	10%
NOT Actively Interested	Flexible	Adaptable at the individual level	80%
NOT Actively Interested	Flexible	NOT Adaptable at the individual level	10%
5NOT Actively Interested	NOTE Flexible	Adaptable at the individual level	20%
NOT Actively Interested	NOTE Flexible	NOT Adaptable at the individual level	0%

Through this process, the CPTs required to parameterize the BBNs were provided by individual stakeholders. These probability tables were then combined into a single BBN model through the inclusion of an auxiliary variable (called 'Stakeholders') that represents the weighted input of each stakeholder (Kjaerulff and Madsen 2008). In our study, each stakeholder was weighted equally entailing that the opinions of each of the stakeholders were viewed as equal. The secondary variables, which had no other variables influencing them in the BBN (also termed stem nodes), were assigned probabilities of 50% for each of the two states.

### 3.1 Workshops

The aim of the five stakeholder driven workshops was to look at the adaptive capacity of a local community to eutrophication from aquaculture, with a ten-fold increase in aquaculture development being a proxy for eutrophication. The only



workshop not held on the island group of Frøya itself was the scientist workshop, which was held at the Norwegian University of Science and Technology (NTNU), for the purposes of getting a more detached view. The workshops all followed the same method described above, and started with Systems Thinking group conceptualization efforts, followed by a BBN session, where the priority issue, as identified in the first part of the workshops using Vensim, was explored further, and from which Conditional Probability Tables were created for individual reporting to add to the group element of the methodology. The BBN-development process also facilitated the capture of further information through the discussions that accompanied the development of these networks. This narrative would further contextualize the importance of different variables, whether the narrative was occurring within a group environment (e.g. during the development of the BBN structure) or individually (e.g. during the population of the CPTs). During the development of a BBN structure, for instance, the stakeholders would invariably negotiate or discuss what variables were more or less important in implementing their adaptation option (i.e. identification of the primary-level variables), giving the variables and CPTs greater meaning. The following is an overview of the systems thinking and narratives of the four different stakeholder groups, leading up to their priority issues.

### 3.2 Scientists

The ten scientists that took part in the workshop, looking at possible consequences of a ten-fold increase in aquaculture production for the local community of Frøya, represented a variety of field of studies, including marine chemistry, political science, economy, ecosystem modelling, philosophy, biology and marine technology as well as representatives from SINTEF fisheries and aquaculture. They were recruited through the Marine Coastal Development program at NTNU, and attended voluntarily based on information in an introductory email explaining the project. Their remoteness from the local population at Frøya coupled with their diverse aquaculture expertise gave the group a unique angle from which to view the hypothesized ten-fold increase in aquaculture production and the effects this would have on the local population in a small coastal community, most specifically Frøya. Though their focus at first was mainly technical, focusing first and foremost on general aspects of aquaculture production and feed problems globally, it soon narrowed itself in on the topic of the local community in and of itself. The discussion focused on living, working and travelling to and from Frøya for these purposes, with some disagreement over whether or not Norwegians, especially highly educated ones, would want to live on Frøya or whether they would prefer to live in Trondheim. Some even felt that the production would likely move off shore and that there would be similar work conditions on aquaculture barges as the offshore oil industry is experiencing today, where the location of one's home is of little importance. The discussion finally settled on a "if you build it, they will come" philosophy. This means, if there are jobs for two people in a family, good schools, good infrastructure, opportunities, after-school activities and other scenarios associated with Norwegian family welfare requirements, the highly educated Norwegian families will come as well, and not just the foreigners. The priority issue that was decided upon in the end was to take a broad look at this

ten-fold increase, and prioritize how this can have a positive effect on the local community in general, and on Frøya specifically.

### 3.3 High School Students Specializing in Aquaculture

This priority issue of the local community also resonated well for the high school students specializing in the field of Aquaculture at Sistranda High School in Frøya, representatives of the future generation of the island community. All the students in the class were present throughout the workshops, and the main topics that came up were attached to problems associated with illness in the salmon production industry. This included discussions on how the nets are being perforated by cod eating through them, the nets rubbing onto rings made of steel holding the construction together, and even perforations created by the illegal fishing of tourists within the 100 meter zone surrounding the aquaculture construction. The result of this is that the salmon can escape, and some spread diseases to wild salmon and destroy their spawning territories there by. This was all tied together with the quality of the salmon keepers on site, which was another topic of great interest to this group of youth. Their focus on this, naturally, was not surprising, given that their field of study would educate them to become just that, salmon keepers. The quality of the aquaculture cages and nets, the feeding process, and the conflicts with fishermen over aquaculture vs. fishing areas were all topics that came back to the quality of the keepers on site. Another topic of great interest to this youth at the local high school was the future of the local community. There was no discussion surrounding the fact that their community was growing. They did acknowledge, though, that some of this growth was coupled with incomplete integration, given that the growth was based on foreign immigrants working in lower waged jobs such as the salmon slaughter and packing factory on the island and Norwegians not mingling with them. These production jobs are jobs that Norwegians do not want, they proclaimed, and they felt that this had led to the foreign immigrants sticking to themselves in smaller groups rather than integrating themselves with those from the local community. They nevertheless preferred this growth though, as it led to a community in growth, better schools, more youth and a feeling that there was an actual future there for them. This latter is also what ended up being their priority issue, namely the development of their local community on the archipelago being positive.

### 3.4 Commercial Fishermen

Community development was important for the commercial fishermen as well. Despite the fact that salmon farming has so far been the most successful and commercialized species of the island community, traditional fisheries are still seeking new possibilities for production and sales, which could save this industry as well. They operate test-fishing licenses for new commercial species, and new niches like whelk (sea-snail), sea cucumber and scallops and many believe these new opportunities can be an important source of income in the future for this group. During the season from May to December, fishermen in the area deliver daily crab from the clear waters of the island region and in 2011 a total of 3.500 tons of edible crab was processed at HitraMat AS (Hitra Food Inc.). The fishermen interviewed in this project naturally had a more focused priority area with regards to aquaculture than the high school students though, given their

choice of profession as business owners and their need to protect this business, though they too, like the scientists and the students, had their local community in Frøya and the positive contribution of aquaculture to its development close at heart and at focus in the discussion. The workshop even started with a caveat that they did not want the workshop to say that they had any problems with the aquaculture industry, because, they were, in fact, very happy with it. A total of five fishermen, representing Norges Fiskarlag, a politically independent organization that is built on voluntary membership, participated in the workshop that were to represent the views of the Frøya fishermen with regards to aquaculture expansion in the area. Norges Fiskarlag was established in 1926 to safeguard the collective interests of the Norwegian capture fishermen, and it is the largest fisheries organization in Norway, with some 7000 members. It consists of eight local chapters spread along county lines, as well as two group organizations (*Sør-Norges Notfiskarlag* and *Fiskebåtredernes Forbund*). Members are both coastal fishermen with small smacks, as well as the crew of ocean-going trawlers, thereby ensuring a broad and encompassing membership base, and the group taking part in the participatory workshop represented the same mix of fishing vessels.

Though their priority issue later ended up focusing on the expected topics of their business surviving, the main topic in this participatory workshop was at first how the fishermen felt they were actually not at all affected by problems associated with the salmon aquaculture industry. This was a completely different narrative from similar participatory workshops with commercial fishermen considering aquaculture in Central California (Tiller, Gentry et al. 2013), where the antagonism against another business competitor to limited coastal areas were adamant. The commercial fishermen in Frøya were clear, however, that they were absolutely in favour of aquaculture on the archipelago, and that there were no conflicts between the industries. The island group had been revitalized by the salmon industry, and they claimed no commercial fishermen had suffered job losses as a consequence of this industry expanding. They emphasized that rather than taking jobs away from commercial fishermen, the industry had actually given rise to an increase in other related industries that were positive for all sectors, as well as new school offerings such as the commercial fishermen major at the local high school. After a while, however, once they had spoken on the topic for a while, they did seem to agree that the commercial fishing industry could in fact suffer, and be downsized substantially because of the competition from aquaculture – in fact – they even agreed that the industry could become obsolete because of not only the salmon industry but also other farmed marine species that demand large areas that currently are in use by the commercial fishing industry. The culmination of the discussion was that the financial aspects trump all others. There are clear overlaps between aquaculture localities and spawning areas for commercial fish species, with the former being prioritized, mainly because the decision making process has been moved from the local municipality to the more centralized political entity of the county, which consists of a group of municipalities and is geographically removed from the municipalities in question. The growth potential for the commercial fishing industry on Frøya is therefore less certain than that of the aquaculture industry, which worried the fishers some, and led to their priority issue being the survival of the capture fisher industry.

### 3.5 Local Enthusiasts

In line with the other stakeholder groups, but with a more concrete priority issue than just a positive development of their community, were the local enthusiasts on Frøya, who were selected using the snowball method as well (Snijders 1992). The group of seven were represented by both men and women; local politicians from both the far right, left and middle; industry representatives and board members; educational leaders; historians; local enthusiast- and cultural prize winners; as well as municipality advisors – many of whom held several of these titles. The first element this group brought up with regards to aquaculture, beyond sheer enthusiasm for all the benefits thereof, was that the main group that had raised any kind of objection to the effects of aquaculture were those that did not live on the archipelago permanently, namely second home owners. This was a group that would complain about visual contamination of the area, such as nets being driven on shore, or lights on the water at night. The group was clearly irritated about these objections from the second-home owners, and clearly stated that the concerns of the main population that actually lived on the islands permanently were those that were prioritized, even if everybody had the right to state their opinions at hearings about new and current aquaculture localities.

What was a concern for this group, however, was the increased traffic to the archipelago as a result of the increase in aquaculture production and how this would only get worse if the hypothesized 10-fold increase were to come true. Even if the future increase in road traffic is diluted by an immense increase in traffic by sea instead, the traffic was hypothesized by the group to at least double regardless, which would be intolerable, even at that rate given the current problems they had with infrastructure at today's rate. They felt though, that even if this was negative, the salmon industry had provided for lights on the island group, which was the critical factor. The local high school had had an enormous increase in applicants to both the aquaculture and the commercial fisheries majors, with the former having had an increase from 1 applicant in 2007 to 32 applicants in 2013 and around 85% of all the students actually stay on Frøya after the end of their education. The largest problem with this increase, in addition to infrastructure, was the lack of qualified applications that were needed to fill teaching positions, which could not be resolved with the increasing immigrant population.

With 15% of the population of the archipelago not being Norwegian, they did concede some societal as well as logistical problems despite all the positive association they had with aquaculture. In 2010, the birth rate of children with immigrant parents on the island was significant, at 41%, which was reflected in the day care situation on the island as well, where at least one day care reports the ratio of foreign children that do not speak Norwegian being at 70%, and only 13 % being Norwegian (Strømøy 2012). They felt the integration at the high school went well, however, though they did acknowledge having observed that the foreign students mostly kept to themselves during breaks, something which was acknowledged by the high school stakeholder group as well. They also commented on having read about loneliness among the foreign youth (Strømøy 2013), and decided that language was the biggest challenge to the integration process on the archipelago. Given that these immigrants are on the island group voluntarily for work purposes, they have no rights to Norwegian language education, as refugees do (New in Norway 2013). They therefore have to learn

the language voluntarily, which often hinders their social integration. By the end of 2012, however, the local government on Frøya decided to go into a dialogue with SalMar, where the official work language is Norwegian, about joint language training for foreign workers to ease integration of these groups into the society (Frøya Kommune 2012, Strømøy 2012).

Moving away from foreign immigrants, however, the group fast reappraised infrastructure as its main issue of concern, with the lack of boat communication being a large problem in addition to the roads not being prepared for the kind of traffic they were experiencing nowadays, and would in the future. The main issue was because they wanted not only foreign workers to come move to Frøya – they also wanted Norwegians, which was in line with what the scientists had suggested as well in their workshop. The local enthusiasts felt that there ought to be no more than 1,5 hours to Trondheim – either by boat or by road – for it to be possible to tempt people in the Trondheims region to make the move to the archipelago Frøya. Another wished for option was a max half hour boat route to Ørlandet, where the main air station for the Royal Norwegian Air Force was recently relocated (The Storting 2012), which would provide job opportunities for two income families where one could conveniently work in Frøya. Infrastructure expansion and planning thus became the main priority issue for this stakeholder group, which was reflected in the development of the future scenarios in the second part of the workshop.

### 3.6 Foreign Workers

Finally, the last workshop consisted of the group whose role in the society was a sub-factor in all the workshops, namely representatives of the foreign workers in the salmon industry on the archipelago. This proved to be a distinctive group, composed of variety of immigrants, a group that is currently relatively marginalized in this local community. This group will soon make up 20% of the population of Frøya but few of these immigrants speak any Norwegian. They are employed in relatively low-skilled, low prestige jobs, particularly in the processing of salmon. These workers are, however, critically important to the future of the industry since the local authorities and employers have been unable to attract Norwegian workers to these jobs. The survival of the industry and the health of the local communities therefore depend on understanding the needs of this group. The workshop clearly indicated that the priority of these stakeholders was inclusion in society. The foreign workers did not want to be on the outskirts of society any more – whether there was a ten-fold increase in aquaculture production or not. They felt that their lack of language skills was inhibiting their ability to move across sectors, to be integrated in the local community, and to have upwards motion in their careers. They therefore almost immediately changed most of the drivers away from environmental factors to more social factors. What this group wanted was for the local Norwegian community to recognize their need to have training in speaking Norwegian in a natural setting. They wanted their fellow island inhabitants to actively help them in their effort to learn Norwegian; they wanted the Norwegians to correct their language respectfully when they said something wrong and to explain the correct way of saying the sentence. They felt that it is currently “us” (the foreign workers) versus “them” (the Norwegians), and they felt that the salmon industry management looked down upon them. These

workers also perceived that they were stuck in both the company where they worked and in Frøya because of their lack of integration and Norwegian skills. This lack of upward mobility options was a great source of frustration and led to lack of interest on the part of many in staying in Norway, and instead dreaming of returning home to their respective home countries.

## 4. Results

Four of the stakeholder groups were located in Frøya, and thus had the same frame of reference with regards to their local community and the changes they had seen and were foreseeing therein. The fifth stakeholder group consisted of experts in the field of aquaculture in general, specifically from a scientific and technological point of view. After the initial part of the workshop, where the group conceptualization process explored and unearthed the priority issue of the given stakeholder group, and the BBN development created the causal links leading to this priority issue, conditional probability tables (CPT) were given to the participants to fill out. The data elicited from the participants were used to construct and compile functioning BBNs using the dedicated Bayesian software package Netica using these tables. Auxiliary ‘expert’ variables were introduced to each of the BBNs (Kjærulff and Madsen, 2007). These auxiliary variables were specified for every child variable within the BBN structure with the contribution of each stakeholder’s CPT weighted equally. The goal was to have the participants create quantitative future scenarios, where they would come up with their user group’s priority issue given the prerequisite scenario of an imagined ten-fold increase. The background for wanting this information was to ascertain a priori what the conflict lines could be in the future for these user groups, and provide a management tool to that would better prepare local and national policy makers to the potential conflict lines that may emerge. The following are graphical representations of the BBNs for the five different workshops. For the purposes of easing the readers understanding of the networks, an in depth explanation of how these work will be presented first. Each stakeholder group was first instructed to assign two (dichotomous) states to their priority issue as a means of discretizing this variable. The priority issues are stated in table 2.

*Table 2: Priority issue in each workshop*

<b>Workshop</b>	<b>Priority issue</b>
Scientists – NTNU	Positive effect on local community
Local Enthusiasts	Realistic infrastructure
Commercial Fishermen	Existence of a commercial fishery on Frøya
Future Generations (High School Students)	Positive development of local community
Foreign Workers in Salmon Industry	Learning to speak Norwegian adequately

The workshop facilitator guided the participants on the selection of these states including informing them that they had to be discrete states (as opposed to continuous), mutually exclusive (only one state can be true at any given time) and that the states be exhaustive (all potential outcomes are covered by the states).

These rules are fundamental tenets of BBN development (Marcot, Steventon et al. 2006) although the selection of dichotomous states entails that these are often broad qualitative descriptions. Conversely, restriction to dichotomous states enhances the tractability of the associated conditional probability tables (described elsewhere), which can otherwise be a serious impediment in BBNs that rely heavily on expert elicitation to parameterize them (Kjaerulff and Madsen 2008).

Further guidance on the selection of the dichotomous states was provided in that the stakeholders were instructed to reflect on a desirable and undesirable state respectively. In the next step of the BBN development process, the stakeholders were asked to identify three primary variables that would directly influence their capacity to manage their priority issue at their desirable state. After some group discussion, the participants agreed upon three primary variables (dichotomous states were assigned as per the priority issue (see the BBN figures under each heading under). The priority issue and the three primary variables and states were then put up on colored post-it notes on the board during the workshop, so that the stakeholders at all times could see what they were deciding upon in unison. This was helpful when the second level of causality (secondary variables) in the developing BBN diagram was created. This process required that they assign up to three variables for each of the three primary variables, based on the concept that these secondary variables directly influenced the primary variables. Again, they were prompted to assign percentage influences that these secondary variables would have on the primary variables. The participants assigned dichotomous states to each of the secondary variables in a similar manner as for the priority issue and the primary level variables. The priority issue and the primary variables (the first and second levels of the pyramid) were the basis for the scenarios produced (see example in Table 1) where the stakeholders then assigned individual probabilities for each scenario being realized. In the figures below, the results of those probabilities have been added to Netica, and the group results are presented.

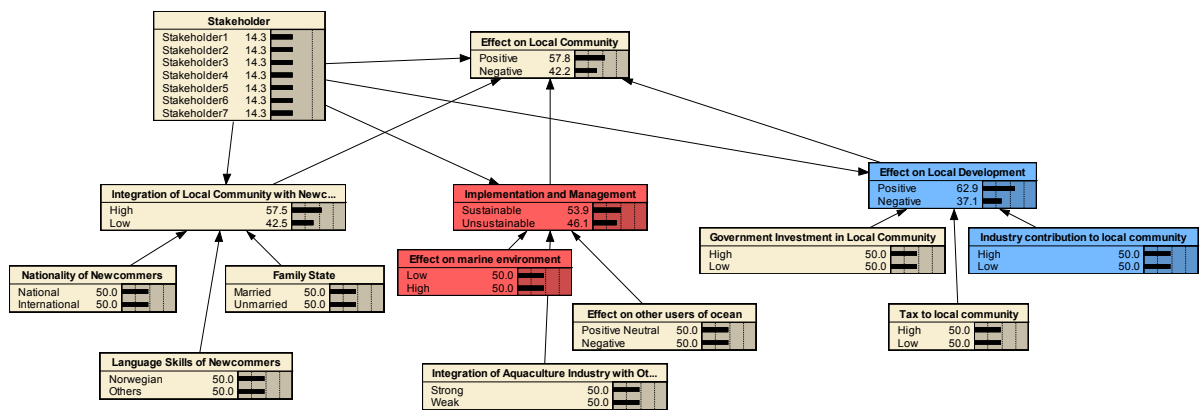


Figure 4 – BBN Scientist Workshop – red is most influential pathway, blue is next.

The scientists had chosen to have as their priority issue, given the instructions from the research team, the need for a positive effect of a tenfold increase in aquaculture production on the local community of Frøya specifically, but also more generally, given that there are many “Frøyas” in Norway. They had a very positive outlook of this, given the results of their conditional probability tables, and all in all, of the 7/10 participants that did fill out the forms after the workshop (3 had to leave early and never filled these out though participated in the workshop), the results showed that they anticipated that with a ten fold increase in aquaculture production, there was a 57.8% chance it would have a positive effect on the local community. This was under the caveat of the production being sustainable, however, with little negative effect on other user groups or the marine environment, and a strong integration between the industry and other sectors in the community. With this lacking, this positive outlook would shrink to only 39% certainty of a positive effect. A low integration, set at 100%, of newcomers to the community was deemed less important, however, though it did make the outlook fall right under 50%. Similarly with environmental sustainability, the third scenario looking at local development, also suffered if the effect on local development was set to 100% negative, making the prediction of positive effects fall to 38.4%. What the initial conditional probability tables show, however, is that the scientists as a group appear convinced that the effect on local development, with 62.9% certainty, will be positive. Based on the narratives from the workshop itself, these results are not surprising. The workshop consisted of scientists with a dedication to aquaculture as a field of specialization, and they were in general very positive to the industry in general and less focused on the environmental aspects that could negatively have an effect on a coastal community. They saw the benefits of this industry as being more prominent than any potential negativity, which was again reflected in their output. Though, as observed in the BBN, the variable with the highest chance of changing the positive outlook was still those that related directly to sustainability of the industry. When doing the sensitivity analysis of the BBN, we found that the *Implementation and Management* node is most influential on the priority node and is mainly driven by the *effect on marine environment* (unsurprisingly for scientists!). The *effect on local development* is also important and the main determinant acting on this is the *industry contribution to local community*. *Integration of*



*local community* is a weak determinant and this is reflected in the sensitivity analysis with all three parent nodes (*family state; language skills; nationality*) the three bottom ranked nodes. Similar to the fishermen, there is a strong stakeholder effect but there is not clear divergence in which nodes are the most influential. This suggests differences in the conditional probabilities but not in the sentiment (or perception) about which are the important nodes in the BBN.

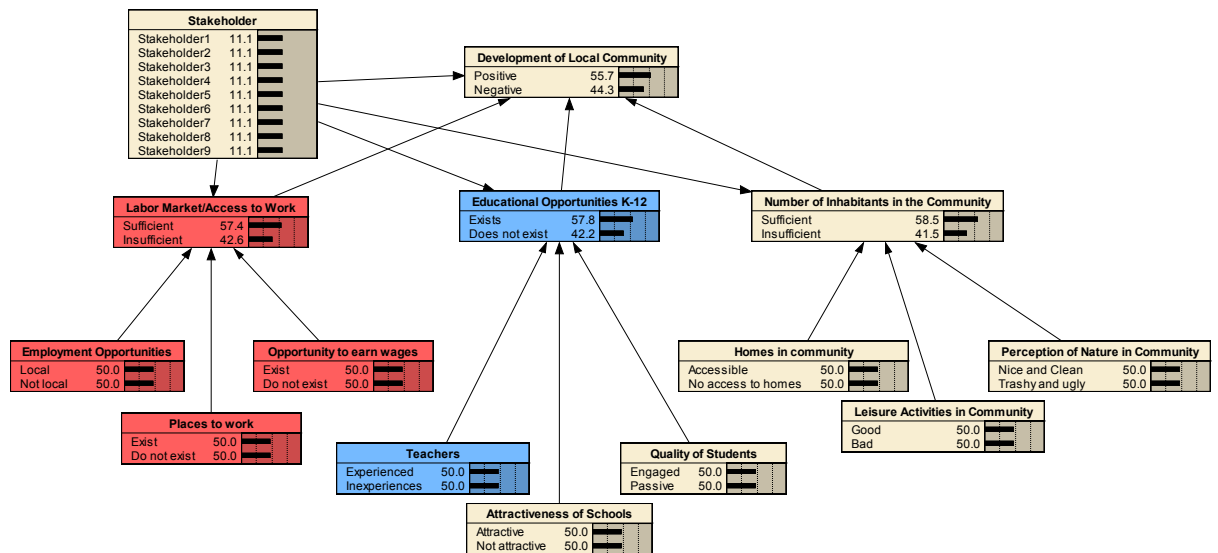


Figure 5 – BBN Future Generations. Variables in red rectangles highlight most influential path, blue indicates second most influential path.

*Labor market/ Access to Work* was the most influential determinant acting on the priority node (*Development of Local Community*) for the local high school students on Frøya. In turn, this (*Labor market/ Access to Work*) was almost equally sensitive to its three parent nodes (*places to work, employment opportunities, opportunity to earn wages*) showing how the students felt that it was critical not only that there were jobs on the island for them in the future, but also that they were local and that they had the opportunity to earn good wages. The second most influential pathway was via the *Teachers* and *Educational Opportunities*, demonstrating the actual importance young high school students place on the experience of their teachers and mentors. Note that the auxiliary variable representing the stakeholder beliefs (*stakeholder*) was also influential, emerging as second only to *Labor market/ Access to Work*. This indicates a divergence in the conditional probabilities assigned by the nine stakeholders. There does seem to be some convergence about the importance of the labor market/access to work among the nine stakeholders, although there is divergence in whether 'employment opportunities', 'places to work' or 'opportunity to earn wages' is more important.

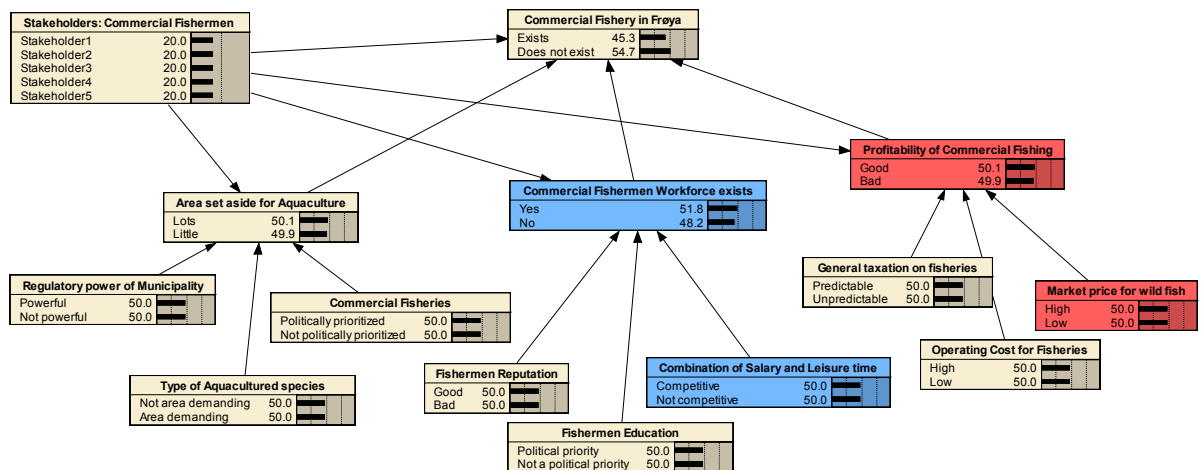


Figure 6 – BBN Commercial Fishermen. Variables in red rectangles highlight most influential path, blue indicates second most influential path.

The importance of work and salary also is evident among the fishermen on Frøya. During the sensitivity analysis it was found that *Profitability of Commercial Fishing* is easily the most influential node in this network and this is predominantly influenced by the *Market price for wild fish*. The stakeholders actually perceived the other two parent nodes for *Profitability* (i.e. *taxation* and *operating costs*) as having quite low influence on profitability, which is understood more clearly when the narrative of the workshop is taken into account. One of the participants was a large-scale business owner with several employees and large costs, and was very set on the critical importance of predictability, given the high costs unpredictability would inflict upon his company. The others were small-scale boat owners and were not equally sensitive to these fluctuations. However, this also demonstrates the flexibility of this system in that it captures what the majority actually felt, discarding what dominant stakeholders in a workshop setting may overlook. The next main pathway of influence is through the node ‘*Commercial fishermen workforce exists*’, although the sensitivity analysis indicates this is a lot less influential than profit, which is not surprising giving that these are business owners and are representing an industry as such. The main influence on *workforce exists* is *salary-leisure* although *fishermen reputation* is also important. The *area set aside for aquaculture* is a minor determinant judging by the sensitivity analysis although out of its three parent nodes, the *type of aquaculture species* is the important one (the *politics* and *municipality* themed nodes are very weak in terms of influence). The narrative shows that this is because of a perceived threat they have of future kelp aquaculture developments on the island, something which they perceived to be much more space needing than the aquaculture industry, thus forcing them further out of their fishing areas. Lastly, stakeholder, as a variable, has considerable influence on the priority node indicating some degree of divergence between the beliefs of the stakeholders themselves. However, looking at the outcomes of the sensitivity analysis, it would seem that this variability probably reflects more the difference in the actual probabilities assigned but does not reflect the underlying sentiment (e.g. two stakeholders share a belief in which parent node is more important but use different probabilities to reflect this).

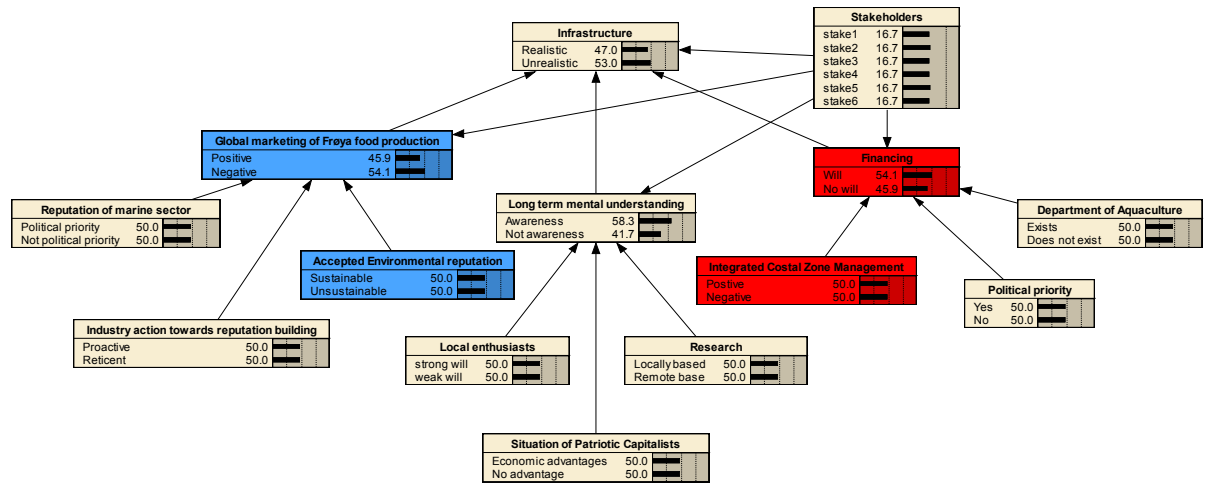


Figure 7 – BBN Local Enthusiasts.

The local enthusiasts chose to be more specific in their quest for a priority issue and the path towards it. Rather than focusing on the positive effects on the local community, which they took as more of a given, and focused instead on how to prepare the community for all these positive effects, namely through realistic infrastructure investments that would take into account this tenfold increase in production on Frøya. Based on the six stakeholders' conditional probability tables, the initial joint results were not entirely positive, with a likelihood of only 47% of "Infrastructure" being realistic relative to the needs of the community. With "Global Marketing of Frøya Food Production" being manipulated to 100% positive, however, this changed to 62.2%. Similarly, with a "Will to Finance" set at 100%, it changed to 62.6%. Despite the heavy emphasis of the group on the importance of "Long term mental understanding" – which meant that the stakeholders felt the global community needed to change its mentality about farmed marine products from the bottom up, at the local community, this variable nevertheless did not change much, even when set at 100% at which it only reaches 55% chance of infrastructure being realistic.

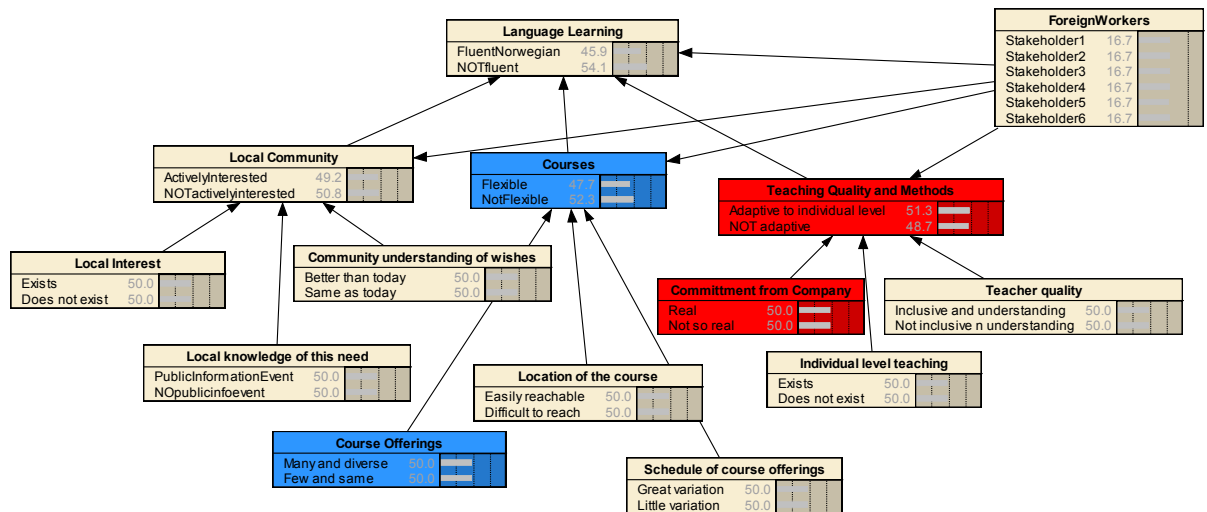


Figure 8 – Foreign Workers in the Salmon industry

The foreign workers, as opposed to the other groups, were not as concerned about the local community per se – but of their role within it. They chose as their priority issue being able to speak fluent Norwegian (Language Learning), and what variables they felt were influential in reaching this end. The initial results showed that, based on the individual probabilities, the participants felt it was almost a 46% chance of them becoming fluent in Norwegian. The most influential variable for them was Teaching Quality and Methods. In turn, the sensitivity analysis (above Table) indicates that ‘Commitment from Company’ is the most influential determinant (of Teaching Quality and Methods) and therefore the most influential pathway to the priority node is via these two variables (as indicated by the red nodes in the diagram below).’ This variable (commitment from company) rests on their view that the commitment from the company to *not* schedule them for mandatory work or overtime when there was a course that they needed to go to had to be real. Although not entirely logical, this was clearly the most important factor for them, Naturally, the adaptive capacity of teaching methods is not related to, or affected by, whether or not a workplace will schedule someone for work in the same period. The two other variables affecting Teaching Quality and Methods are, however, but these were not equally important to the participants. This showed that in addition to their need for good teachers, they had an underlying assumption that there had to be a real commitment from the company to let them learn fluent Norwegian on their own time and according to their own schedule, and without the company demanding work over language. There is general cohesion about which nodes are the most important and which are least important among the stakeholders too. Four out of the six stakeholders placed Teaching quality and Method as the most important variable influencing the priority node. Furthermore, five of the stakeholders placed Commitment from the company as the most important node influencing Teaching quality and Methods. The main divergence from this pattern was stakeholder 6, who appeared to place greater on Local Community (and Local Interest).

Based on the sensitivity analysis, the second most influential node is ‘Courses’. At the next hierarchical level (i.e. the parent nodes for ‘Courses’),

‘Course Offerings’ is the most influential with the remaining two parent nodes having similar (but lower) influence. This second-most influential pathway is shown in blue in the following BBN. There is more variability (or divergence) regarding the second-most important node influencing the priority node, which was split between ‘Courses’ and ‘Local Community’. The greater influence given to ‘Courses’ in the group-level sensitivity analysis appears to be a result of more widespread probabilities assigned to the effect of Courses (i.e. the impact of whether these were flexible or not) and the low importance assigned by one of the stakeholders (Stakeholder 4).

## 6. Conclusion

The implications of the findings of these workshops to policy makers are many, both at the local, regional and national scale. Policy makers are constantly faced with both the interests of new investments that could provide job opportunities and increase seafood production, and also existing constituents, including stakeholders with different levels of power and influence over policy decisions. It has been argued that stakeholders should play a large role in determining public policy in a given area. This is because it facilitates legitimacy in the process for the stakeholders, greater satisfaction and often more innovative solutions (Gopnik, Fieseler et al. 2012). Policy makers’ a priori knowledge of these variables can lessen conflicts that may arise as a result of stakeholder discontent with top-down approaches to aquaculture management, and give managers a better understanding about what they propose could have negative repercussions with stakeholder groups. It can also bring a legitimizing aspect to the political process for affected stakeholder groups, possibly lessening simmering conflicts.

In light of this, the article has explored the socio-ecological effects of a ten-fold increase in aquaculture production through the granting of new licenses to the industry around the island group of Frøya in Trøndelag, Norway. This was investigated from a stakeholder perspective, assessing the adaptive capacity of the local community Frøya in the middle part of Norway to a ten-fold increase in aquaculture production. This was done through participatory stakeholder workshops combining Scenario Analysis, Systems Thinking and Bayesian Belief Networks, where we developed conceptual frameworks and influence diagrams visualizing the perceived effects of the industry on the given stakeholder system. This adaptive capacity is, even in its raw state, an important tool for policy makers to explore the effects local communities foresee with de facto industry expansion. This can then provide context-specific adaptation policies and measures that can be pursued that reduce a given stakeholder group’s vulnerability to negative consequences of industry expansion.

A few assumptions were proven wrong in this project. Beforehand, it was expected that the challenges of integrating an increasing number of foreign immigrants into the small island community would be a priority issue for many of the stakeholder groups. We also expected income to be a priority issue for commercial fishermen, and that environmental issues would be of big importance to the stakeholders. However, we were surprised by the results, especially since there was an apparent lack of conflict over even something as dramatic as a tenfold increase in aquaculture production in the relatively small geographical

area of the archipelago of Frøya in Norway, even in light of known environmental effects and displacement of other user groups and how much more integration need would result from it. The survival of the island community was that which was of utmost importance in these communities, and with expressed gratitude towards the industry saviours that were contributing to this growth and the foreign immigrants that were contributing to it. Underlying all this positivism, however, is the fact that there are definite integration issues prevalent in the community that now has near 20% foreign inhabitants, and where day-care centres can have upwards of 70% non-Norwegian speaking children attending. “If you build it, they will come” was resonated in the workshops, with a reference to native Norwegians, not foreign workers, and that an increase in population as a result of a tenfold increase in production could as easily be filled with Norwegian migrants as foreign ones, if only the infrastructure challenges, as relates to the necessity of two jobs per family, could be overcome. When exploring the other side of this issue, the foreign workers, we did find that there were simmering conflicts where they felt marginalized on the outskirts of society at times and wanted to be included. One worker summed it up nicely when she said: “...if I could speak fluent Norwegian, and be part of society, I would stay here forever!” This is important information for the policy makers at all levels of management to understand and to act upon before increasing licenses for aquaculture in remote areas along the Norwegian coast. Unless you have a workforce of Norwegians ready to fill the associated positions for these new licenses, there needs to be critical work done in the language acquisition area so that the foreign migrants that come to Norway are integrated properly and become part of the population rather than transient workers.

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