Due Delivery date:
June 30th 2016

Authors:

Hugo Salgado
UTALCA
e-mail :
hsalgado@utalca.cl

Jennifer Bailey
NTNU
e-mail: Jennifer.Bailey@svt.ntnu.no

Rachel Tiller
SINTEF
e-mail: *rachel.tiller@sintef.no*

OCEAN CERTAIN
FP7-ENV-2013.6.1-1
Project number 603773

Deliverable 3.5
Report on local stakeholder perceptions in Chile

WP's leader: NTNU
Task leader: UTALCA

Principal investigators:
Hugo Salgado, **UTALCA (C)**

Project's coordinator:
Yngvar Olsen, **NTNU** (N)

1. INTRODUCTION

In deliverable D3.5, we present results from stakeholders' workshops for the Chilean case for gathering information directly from stakeholders to build participatory models. The goals of these workshops are (a) To understand stakeholders' concerns regarding the effects of climate change on their communities, (b) To present the socioeconomic vulnerability model and to obtain information to adapt this model to stakeholders' local reality, (c) To build system thinking and BBN models that conceptually represent stakeholders' perception, concerns and relevant information.

The workshops for Chilean stakeholders were held in the locality of Cochamó in the Reloncaví Fjord, which was the site chosen for the application of the Ocean Certain models to the Chilean reality. We conducted two stkeholder workshops with members of the local community of Cochamó, on July 22th 2015 in the offices of the Cochamó fishermen's cooperatives. The cooperative's help was crucial for getting the involvement of the local community and their associates to participate in the meetings. The location of Cochamó in the Relocanví Fjord can be seen in Figure 1.

Cochamó locality is a one-street small rural location but one of the most populated and easily accessible from Puerto Montt in the Reloncaví Valley. The Municipality of Cochamó has a total area of 3911 square kilometers and about 4000 inhabitants. It is located at the the point of entry to the Cochamó Valley which is known as the "Yosemite of South America" and it is one of the new favorite specialized tourist destinations for trekking, rock climbing and kayaking. In this sense tourism in the community is not related to the ocean, but as it will be clear later as a result of the workshops, ocean-related activity could become important for the local community as it adapt to the negative effects of climate change in fisheries and aquaculture.

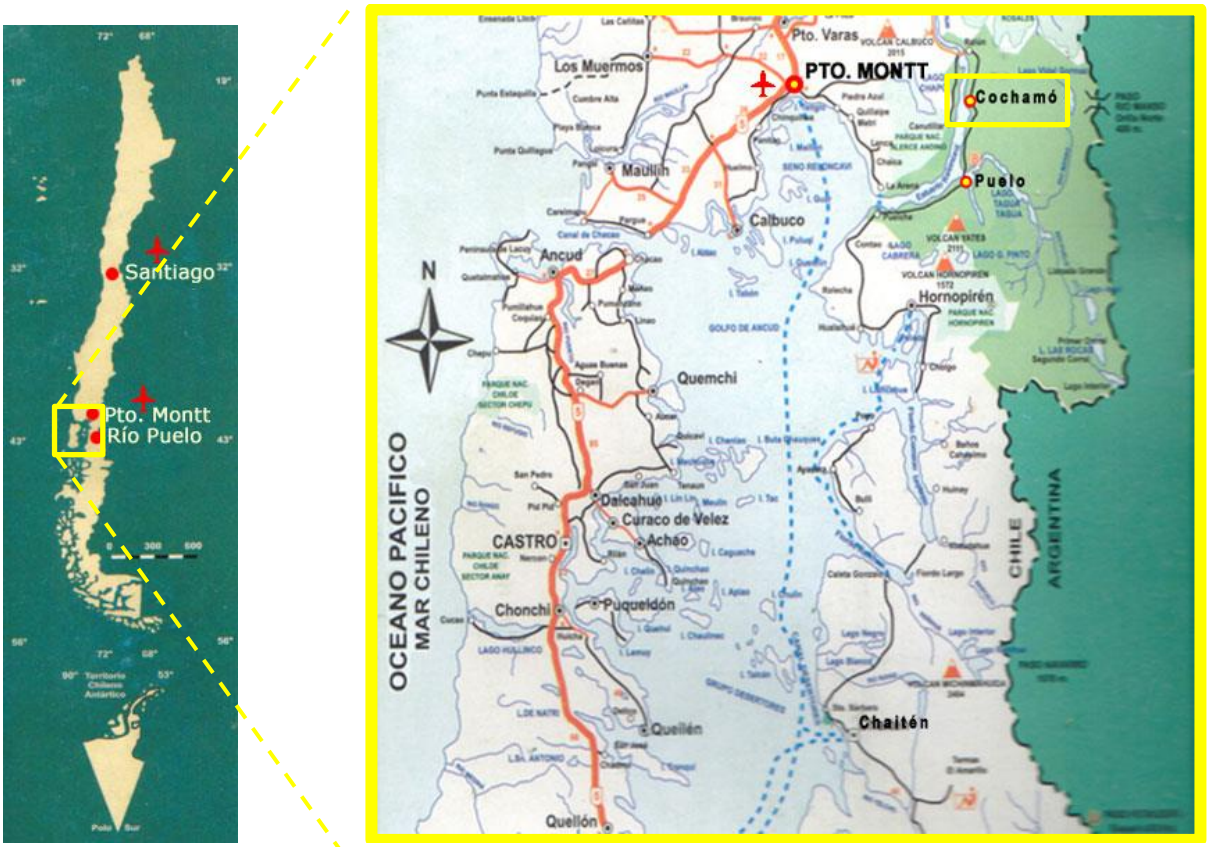

Figure 1. Location of the community of Cochamó in Chile.

We conducted two stakeholder workshop in Cochamó. Artisanal fishermen and small scale aquaculture/mussels seed collectors participated in the first workshop. In the second workshop members from the community mostly related to the tourism sector were present. Unfortunately, we were not able to get the aquaculture firms to participate in a specific workshop. Additionally, we had another workshop in the city of Valparaíso, where the offices for the fisheries management body is located (Undersecretary of Fishing, SUBPESCA and SERNAPESCA, the enforcement agency). In this workshop representatives from the Ministry of Economics, the Undersecretary of Fishing, the Ministry of the Enviroment and consulting companies working in the Climate Change Adaptation and Mitigation Plan for the Fisheries and Aquaculture Sector in Chile participated.

This work was carried out as described in task 3.4: *Assessing Local Vulnerability by Stakeholder Participatory Model Building (answers objectives 2,3,4,5, 6 and 7 of WP3)* and more specifically in the following sentences:

1) "*...conduct several highly participatory stakeholder workshops in one community...in Chile...and to spread scientific and project information...*";

2) "*...researchers will engage with stakeholders to establish the degree to which they perceive that seven climatic and non-climatic stressors under study by OCEAN-CERTAIN may impact the natural marine resources upon which the selected communities rely and how end-user stakeholders perceive threats to their livelihoods.*";
3) *"The workshops will employ two key methodologies: Systems Thinking (ST) and Bayesian Belief Networks (BBNs) methodology.";*
4) *"...stakeholders will create shared "mind maps" of their SES [social-ecological system] as they experience it, resulting in the collective identification of elements of the system that stakeholders hold to be more or less significant with respect to their economic activities and welfare..."*

In the DOW, the description of Deliverable 3.5 is: "Report on the first round of stakeholder workshops in Chile, including the results of the "systems thinking" exercise (capturing the group-level understanding of how their socio-ecological system works), the individual level conditional Probability Tables . . . and any information derived from these. The report will include any relevant aspects of the "narratives" (stories and explanations) that support stakeholder views". Note that including the individual conditional probability tables (CPTs) was not a good strategy. These make little sense on their own. Instead, the combined results of these tables is reported as the Bayesian Belief Network (BBN) Model for each workshop. The creation of the BBN models is the objective of producing the individual CPTs.

2. Summary of contribution of involved partners to deliverable

Partner 11, UTALCA, led the work of D 3.5, and led all workshops, and reported on these.
SINTEF and NTNU collaborated in the redaction of this report.

3. METHODOLOGY

We used an integrated approach of Systems Thinking (ST) and Bayesian Belief Network (BBN) modelling in developing the stakeholder-driven scenarios and gaining critical insight into the adaptive capacity of the local stakeholder group. Systems Thinking as a methodology was used to develop shared mental models of the 'system' as perceived by the stakeholders involved, with a resultant conceptual model. This step provides a conceptualization of stakeholders perception of their socioeconomic system based on the shared stakeholder knowledge and experiences and helps identify what of the presented drivers are the most relevant for the specific location, together with analyzing the consequences perceived to be important for them. This ST process also helps in identifying important elements within the system conceptualization that have influence over, or are influenced by, other elements within the same system. A benefit is that it allows exploration of a complex system at the local scale based on the expertise of the

stakeholders themselves. The system conceptualization was also used to identify and select a 'priority issue' that was further explored using BBN modelling, and which uncovered other aspects of the issue. This priority issue represented an element or theme that emerged from the system thinking process that the stakeholders believed to be the most important issue to address in the context of the developed model. Vensim, a software specifically designed for systems modelling and developed by Ventana Inc., was used to develop the system conceptualization during each workshop.

There is a strong motive for engaging with stakeholders in order to access the expertise that they possess (i.e. 'knowledge-base' data), which is characteristically strongly qualitative. For example, the fields of climate change adaptation and resource management have strong human dimensions and therefore draw heavily upon this knowledge-base. However, quantifying this narrative-rich knowledge-base for the purpose of making management decisions (e.g. adaptive management scenario testing) is difficult. On these grounds, BBN modelling was selected as the methodological framework for further exploration of the priority issue. In addition, it was chosen because it facilitates participatory modelling and is well–suited to representing causal relationships among variables in the context of variability, uncertainty and subjectivity. Furthermore, BBN modeling is a method that is extremely well suited for coalescing knowledge, even if this knowledge comes from a variety of sources (e.g. stakeholders) and is of a variety of completeness, into a single modelling framework (Tiller, Mork et al. 2015). It is particularly effective in eliciting stakeholder opinion through participatory engagement because of the following two reasons:

1) **Firstly**, the visual aspect of developing the causal maps that characterize Bayesian network models are easily understood and readily accomplished (as confirmed in our experience) by the stakeholders. The impact of this should not be understated, as this fosters trust during the stakeholder engagement process.
2) **Secondly**, the robust mathematical framework of Bayes theory underpins these models. This aspect, whilst not necessarily obvious to the stakeholders, provides a mathematical basis for incorporating the beliefs of the stakeholders into the model, something that traditional statistical approaches (e.g. null hypothesis testing) does not allow. They have also demonstrated ability in utilising subjective expert opinions to both derive the structure of, and variables within, a BBN (Richards, Sanó et al. 2013).

The methodological process of developing BBNs through stakeholder engagement is outlined in detail elsewhere (Richards, Sanó et al. 2013; Tiller, Gentry et al. 2013). Briefly, however, the structure of a BBN is a network of nodes that are connected by arcs. Each node is treated as a variable and therefore must have more than one state (e.g. if 'car color' is the variable, then the states could include 'white', 'red', 'blue' etc). Furthermore, these states must be mutually exclusive (a variable can only have one state at a time), exhaustive (the states cover all possibilities e.g. for car, the variable color would entail that all possible colors must be assigned as individual states, or alternatively, the states defined in a way that covers all possibilities e.g. 'white cars', 'not white cars') and consistent (i.e. the states must relate to the same variable). Arcs connect variables and show the direction of causality through the direction of the arrow at the end of the arc – this direct connection between variables represents conditional dependence, which is a fundamental tenet of Bayes theory upon which BBNs are based.

Feedback pathways are not allowed in Bayesian networks and therefore the entire network must be acyclical (i.e. one direction of causality). The implications for this constraint include the inability to model the influence of reinforcing (positive feedback) or balancing (negative feedback) pathways on the system being modeled. Such feedback pathways are important for understanding the temporal evolution of a system (i.e. how it changes overtime) and how it might respond to 'perturbations' (Sterman 2000). Whilst there are techniques that can enable feedback pathways in BBNs these can quickly lead to cumbersome models with a large amount nodes, even for very simple feedbacks (Kjaerulff and Madsen 2008). If the purpose of a model is to explore the role of feedback pathways in governing temporal dynamics then other modeling methodologies such as systems dynamics (Sterman 2000) would be more appropriate to use than Bayesian statistical modeling. However, in our modeling, we are interested in using a methodology that allows straightforward integration of multi-disciplinary (environmental, social and economic) variables, accommodates 'expert opinion' as a data source and where models can be developed even when data is relatively scarce. Furthermore, in our work we are focused on **scenario analysis** (i.e. what if?) where changes in conditions (for instance more aquaculture licenses with localities requirements in the northern part of Norway) may be used to update our prior understanding of an event (e.g. the priority issue in our model) to posterior understandings. These ideals are well-matched by the attributes of BBNs.

The other main component of the BBN is the set of conditional probability tables (CPTs) that quantitatively define the conditional dependence between linked nodes. In the workshop setting outlined in this paper, the perceptions of the stakeholders are used to populate these CPTs with probabilities, quantifying their beliefs about the relative importance of different variables within the network. The underlying probabilistic framework (i.e. Bayes theory) provides a mechanism of directly integrating social, economic and environmental variables within a single model (Kjaerulff and Madsen 2008). During the workshops used in this study and elsewhere (Richards, Sanó et al. 2013; Tiller, Gentry et al. 2013) development of the structure of the BBNs is a group-level exercise. That is, it represents the group-level belief about which variables are included and how arcs connect them. Therefore, this process typically requires negotiation between the stakeholders. Conversely, each stakeholder populates the CPTs with their probabilities providing individual-level parameterisation. The individually-parameterised BBNs can then be combined into a single model as they share the same structure but have different CPTs. This is achieved here by using an auxiliary variable(Kjaerulff and Madsen 2008), which weights each of the individual stakeholder CPTs so that the beliefs of one stakeholder can be given more weighting in the model than others. For this study the stakeholders were weighted evenly. Finally, the BBN-development process facilitates the capture of further information through the discussions that accompanied the development of these networks with this narrative providing important context to the importance of different variables during the workshops.

4. STAKEHOLDER WORKSHOPS & LOCAL PERCEPTIONS

4.1 Introduction

Chile is one of the countries in the world where some of the effects of climate change and environmental variability have been felt in the last decade. In fact, the Chilean government has taken decided action to introduce climate change as one of their strategic priorities in the policy making process. Climate change has also attracted the attention of the academia for almost 20 years and the discussion has entered into public opinion. In fact, a recent public opinion survey in the three major cities of the country revealed that climate change is considered the third most important environmental problem, after air pollution and waste management. The dependence of the country's economy on natural resources, agriculture and the wine industry, the importance

of agriculture, the dependence of electricity production and agriculture activities on rain and water runoff from mountains, the extensive coast and the importance of fisheries and aquaculture for coastal communities have probably been key factors in the relevance of this topic for the country.

The Chilean government have been developing important policies to deal with adaptation and mitigation to Climate Change. In fact, the government ratified the UNFCCC in 1994 and established a National Advisory Committee in 1996. A first national communication was given in 1999 and a second communication showing important progress was given in 2011. Since then, Chile has adopted important policies, such as a National Strategy for Climate Change in 2006, and sectorial strategies in different sectors. An updated National Strategy, including an Adaptation and Mitigation Plan for Fisheries and Aquaculture was approved by the congress in December 2015. Climate Changes is one of the five thematic focuses of the recently (2010) created Ministry of the Environment.

A stakeholder workshop requires preparation, including the determination of the vantage point for the discussion. The Ocean Certain project sought a common vantage point for all stakeholder workshops. Workshop organizers accordingly started out with the general The model in Salgado et al. (D3.3) used 8 drivers, specifically decided upon by the members of the scientific consortium of Ocean Certain. These drivers were:

1) Food web;
2) Biological pump function;
3) Sea Surface Temperature;
4) Ocean CO2;
5) Ocean Acidification;
6) Water Quality;
7) Water Pollution; and
8) Algal blooms.

A stakeholder in general has been defined by the literature as "…any group or individual who can affect, or is affected by, the achievement of the organization's objectives" (Freeman 2010). This is a broad definition and leaves the concept of having a stake, or invested interests, unequivocally open to include virtually anything, any topic, and the jurisdiction of a given

stakeholder open to anyone. The sector chosen in Ocean Certain were Fisheries, Aquaculture and Tourism sector. Therefore, we went to the local community and looked for stakeholders related to these three sectors.

Finally, Policy and management was considered as a critical element of stakeholder inclusion as well. This is because government has been key on incorporation the issue in the public and academic agenda and they have been recently working in the update of the National Action Plan and the Mitigation and Adaptation Strategy for Climate Change in the Fisheries and Aquaculture sectors. The new action plan involves a number of actions that could be crucial for the dissemination of Ocean Certain project and to which the decision support system that will be developed could be an important contribution.

The participation of the community in the workshops was strongly supported by the president of the local fishermen cooperative and the workshop was organized in their own offices. This helped us to locate people in the community and obtain their trust to participate as indicated by their local leader. This has shown to be an extremely effective strategy to obtain local community participation.

4.2 First workshop: Small scale fishermen, aquaculture and mussel seed collectors.

The fisher workshop was held during the morning of July 22nd, 2015. There were 17 members of the fishermen cooperative participating in the system thinking exercise but only 12 of them stayed during the second part of the meeting for the BBN construction. These members of the community considered themselves as self-employed in different activities including small scale fishing, small scale aquaculture, divers or services providers for aquaculture companies and mussel seed collection. Currently, the most important activity for this group is the mussel seed collection because all the other economic activities have shown an important reduction in the last 5 years, after the ISA outbreak in salmon aquaculture (which moved aquaculture facilities south to other regions), overfishing and regulation of wild fish stocks, and other environmental extreme events that affected the ecosystem, such as the recent eruption of the Calbuco volcano in April 2015, which seriously affected the fjord with ashes.[1]

[1] A video with the news of the Calbuco eruption can be seen at http://edition.cnn.com/2015/04/23/americas/chile-volcano/

The Reloncaví fjord has an extreme importance for the collection of mussels seeds for aquaculture. These seeds are collected in the fjord from natural banks using long line seed collectors. This is similar to a small scale aquaculture facility, with the only difference that the work concentrate on installing the collectors and maintain them during the season to let the seed growth to a size that is suitable for selling it to aquaculture companies that then put them in their facilities to then process them as industrial canned products. These aquaculture facilities are mostly located outside the fjord southern in the X region (Los Lagos) and XI region (Aysén).
In the last few years these fishermen have seen a number of environmental effects already that might be somehow related to climate change but also related to other stressors such as overfishing, poor spatial and marine management and pollution from aquaculture. This fjord is well known for having suffered from the rise and collapse of the salmon aquaculture industry during the ISA break in 2010 during a period where the aquaculture industry developed with very few restrictions and regulations. In that sense this community has needed to find new ways of maintaining its livelihoods and they have already shown a high degree of adaptative capacity.
It is very interesting how fishermen are well informed about the environmental relationships between the stressors chosen and the environmental goods and services that support their community, focusing mostly on seed collection as their main current economic activity. This can be seen in the System Thinking diagram that is presented in Figure 2.

One of the most interesting results of this workshop is that members of the community have been facing many alterations in their social and economic activities in the last decade. Their main economic activity before 2000 used to be fishing and agriculture with a self-sustained rural economy. During the first decade of 2000 as the country and the region economy developed with the rising of the salmon and trout aquaculture industry in the Reloncaví fjord, the old fishermen started working for the aquaculture industry, young generations migrated to the city of Puerto Montt and new products and services arrived to the community when the route to Puerto Montt was paved. They became more connected but also more dependent on the country's economy. The fishermen also saw a reduction in fishing activities mainly due to overexploitation. In 2010 a big sanitary crisis hit the salmon industry and most of the facilities in the fjord were abandoned, many of them left as ruins with a big environmental impact. Additionally, the fishermen started to implement seed collectors to obtain mussel seeds that were demanded by the mussel aquaculture and canning companies in the south of the region. Artisanal fishermen saw a new business opportunity in this activity and they adapted to the new market demands. After

several years of high profits Artisanal Fishermen/Seed Collector for Mussel Aquaculture have seen their business affected by a low productivity of their activity. In the narratives of the workshops it can be seen that they think this is due either to pollution and environmental effects from the salmon aquaculture industry or due to other environmental factors that they associate to climate change. Recently, they have experienced the eruption of the Calbuco volcano, which had not erupted in the 40 years The ashes from the volcano affected very strongly the community and went into the fjord creating changes in the chemical characteristics of the water and the ocean floor. In the last few year communications to the area have improved as a new touristic attraction was discovered in the Cochamó Valley; it has attracted international and specialized tourists that are looking for undiscovered places for rock climbing, trekking and kayaking. An important eco-tourism industry is flourishing and the Cochamó locality is the door of entrance to the Valley, which they see as a new opportunity to adapt to the effects their changing economic activities are facing. All of these narratives show an important adaptative capacity of the community.

The ST diagram shows the focus of the first group of fishermen in their currently main activity (mussel seed collection). They mention that the drivers presented will affect the few fishing resources they have left through the introduction of harmful alien and invasive species. They also mention as one of the main drivers the change in SST which is affecting the quality and characteristics of the mussel seeds, which is reducing the productivity (and therefore the profitability) of their activities.

They also consider that due to weak regulation and enforcement, the aquaculture industry has polluted and affected the ecosystem, reducing the growth and quality of the natural banks and mussel seeds. See level rise and water runoff into the fjord is another of their concerns as they change the tide and currents regimes. They have already seen important changes in tides regimes and water temperature and level. According to their perceptions, these have affected the deepeness of the intermareal resources they fish and collect and also the seed distributions and paths within the fjord. Also, with higher tide variation, they need to have their collectors at a deeper level which affect their technology, gears and the cost of their activities. Given that they need to have permits that have a concrete spatial delimitation to develop their activities, and these permits are difficult to obtain (it might take years to obtain one), they have not much options to move their collectors to face these changes in currents and tide regimes.

Water pollution from the increasing and developed community and tourists is also a concern, as the fjord has a low recharge water rate which also affect the carrying capacity of the fjord for aquaculture and other fishing activities. Finally, they consider that all these changes will imply less and lower quality jobs.

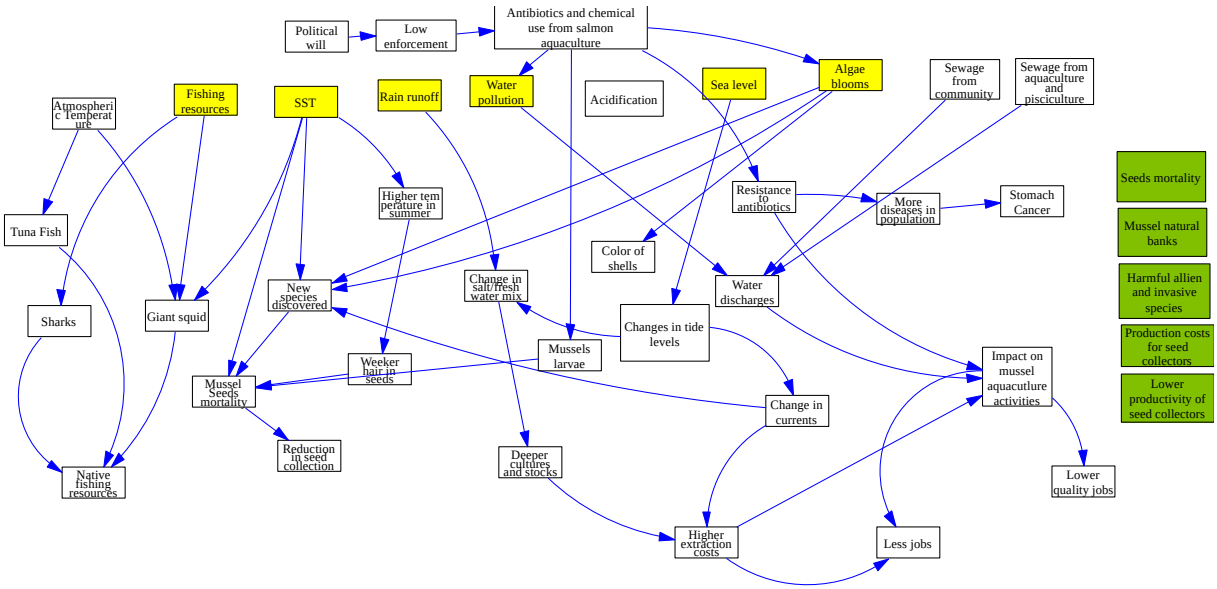

Figure 2: ST Map from artisanal fishermen/seed collectors in Cochamó

When fishermen are asked to choose a priority issue and to complete a Bayesian Belief Network, they choose the "Productivity of Mussel Seed Collectors" as the most important factor. The three main determinants of having high productivity (desired state) are "Seed mortality", "Spawning of natural stocks" and "Seed quality". To obtain low Seed Mortality, they consider that they need "high oxygen in water", "abundant food for seed" and "normal temperature". To obtain "abundant spawning" they consider they need "high reproduction capacity in natural stocks", "high renewal rate of natural stocks", "high availability of plankton". Finally, to have high quality seeds, they believe that they need low pollution from aquaculture, food available for seeds and low water pollution from community and touristic activities.

When averaging stakeholders' expectations of these scenarios, their views are very positive in all these aspects. All the desired scenarios have beliefs of occurrences higher than

60%, with high productivity of collectors being the lower with 63.2% and the oxygen in water being high the highest with 77.7%.

A sensitivity analysis of these results is presented in Table 1. These sensibility analysis shows how the beliefs of the stakeholders for the main scenario change as a finding are obtained in the child nodes (a given scenario is assumed keeping the other constant), according to the conditional probability tables that express how probable is a change in a scenario when a child node changes.

Other than a change in the parent node (Productivity in seed collectors, the higher variability occurs among stakeholders (as we change among stakeholders, the belief of the productivity of collectors change in 8.36% (mutual information of this node compared with mutual information of the parent node). Among the first level nodes, the one that has the highest impact on stakeholders is seed spawning in mussels (5.8% of mutual information), followed by quality of seed (5.1%) and seed mortality (3.9%). Among the second level child nodes, the most important are "Oxygen in Water" (1.3%), "Temperature" (1%) a "Renewal rate of natural stock" (0.6%).

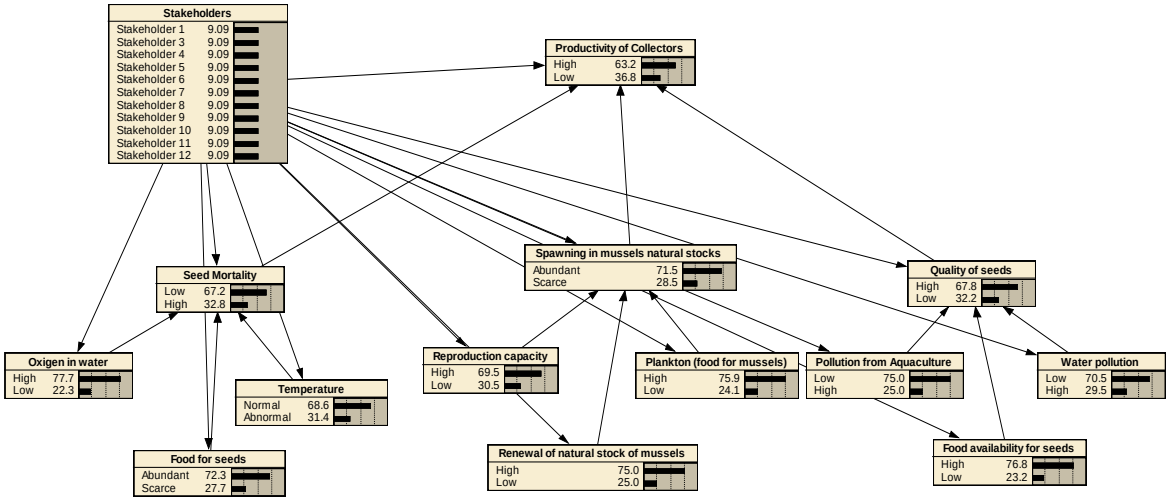

Figure 3: BBN from artisanal fishermen/seed collectors in Cochamó

Table 1: Sensitivity analysis of BBN for seed collectors in Cochamó

Node	Mutual Info	Percent	Variance of Beliefs
Productivity of Collectors	0.94900	100	0.2325327
Stakeholders	0.07933	8.36	0.0247989
Spawning in mussels	0.05523	5.82	0.0181881
Quality of seeds	0.04799	5.06	0.0157222
Seed Mortality	0.03722	3.92	0.0121836
Oxigen in water	0.01235	1.3	0.0040753
Temperature	0.00954	1	0.0031128
Renewal of natural stock	0.00586	0.617	0.0019168
Pollution from Aquaculture	0.00569	0.599	0.0018609
Water pollution	0.00562	0.592	0.0018316
Reproduction capacity	0.00505	0.533	0.0016465
Food for seeds	0.00505	0.532	0.0016486
Food availability for seeds	0.00404	0.425	0.0013200
Plankton (food for mussels)	0.00166	0.175	0.0005413

3.2 Second workshop in Cochamó

A second workshop was hold in the afternoon of July 22nd in the locality of Cochamó with a different group of members of the community. The group in this workshop showed a higher variability composition and included former fishermen, fishermen's spouses, members of the local radio station, fishermen engaged in fishing tourism (they visit the fjord in their fishing boats) and a member of the local navy who was in charge of enforcing fishing operations and permits. This broader view allowed them to review almost all the effects of climate change on their community, reviewing the impacts not only on fisheries, aquaculture, seed collection and tourism, but also they look at the effect of changes in temperature and weather on agriculture, honey-bees and crops irrigation.

The mental map of the discussion in this workshop is presented in Figure 3. We observe in the left that when they were asked about the probable effects of climate change in their community they started by discussing the effects they have already perceived on irrigation, crop growth and honey bees. They mention that extreme temperatures are now more common in Cochamó and that this had have an effect on the growth of crops (they provided examples of apple trees being less productive with less fruit of lower quality) and also higher variability in their crops year to year. These are important activities they engage in, in their SES. We had to make an effort to invite them to talk about the effects of climate change in the ocean activities.

The first ocean activity they related to climate change was the availability of natural fish stocks that they used to fish in the past and that they consider now that the small amount of fish left will be affected by climate change. They mention "robalo", "pejerrey" and "jurel" (mackerel) as the most important resources they fish and that might be affected by climate change. After this, they react to the effects over the fjord that salmon aquaculture has left after the big expansion of this industry and the subsequent abandonment of the fjord by these companies. They consider that the use of chemicals and antibiotics have affected the properties of the ecosystem in the fjord. Also, they consider that the bad treatment and disposal of waste from production and mortality, and the diseases from salmon have affected the population of the native species and the ecological characteristics of the fjord. They also mention that pollution and bad treatment of the wastes from houses and cities around the valley have an important effect on the natural ecosystem and native fisheries. They recognize that other human stressors

have a bigger impact than environmental variation, but also that the extent to which the changes are due to human activity or to climate change, it is unknown. Other effects they consider are those that affect the fjord as a touristic destination. They consider that pollution, eutrophication and even the recent volcano eruption, have affected the properties of the water (affecting its color and its capacity to resist and dissolve pollutants) and that it has a negative impact on tourism. Finally, they consider the effect of oxygen levels in the water, mentioning that it affects eutrophication and the growth rate of mussels. They discuss that many of the drivers directly or indirectly affect the mussel collection activity in the fjord, which can be seen as the one that obtains the higher number of arrows and the wider connection with many topics in the diagram. This can be explained because they perceive that climate change will affect mussel aquaculture and seed collection, which is currently the most important economic activity of the fjord.

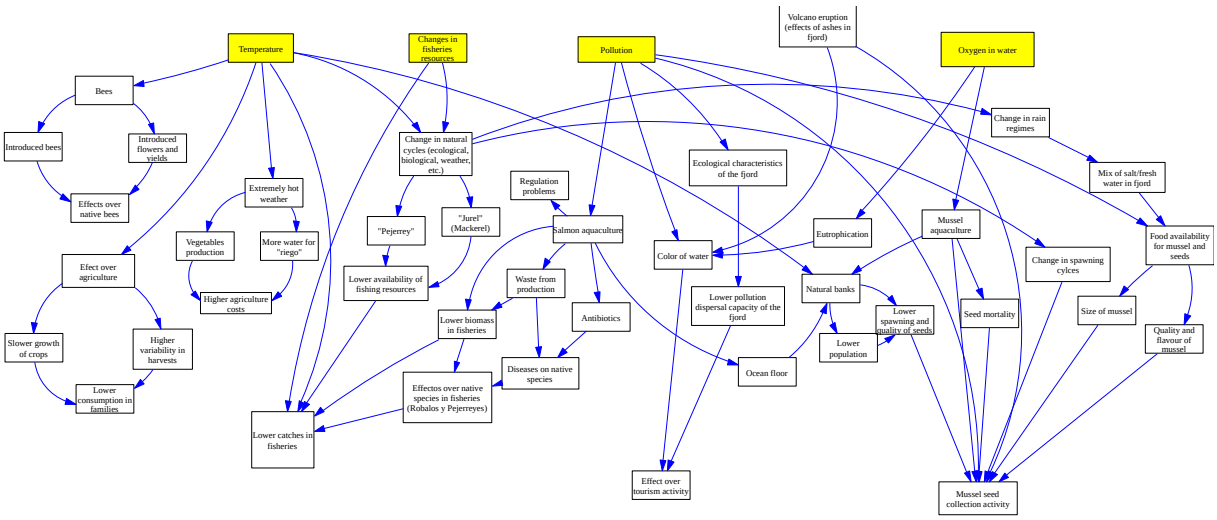

Figure 3: System Thinking Map for Second Workshop in Cochamó (The Community Workshop)

In the narratives of the workshop stakeholders show the adaptive capacity of the community to the changes they have observed. They mention that in the old days, most of the members of the community were fishermen and that after natural stock collapsed, they were working in aquaculture and seed collection. Given the problems that they have experienced in these activities recently, most of them have looked for opportunities in the tourism sector.

With this very wide and complete view of the effects of climate change in their SES, this group of stakeholders choose the "development of tourism" (they mention eco/rural/adventure sustainable tourism as their goal) as the most important issue to be addressed. This clearly shows

the adaptive capacity of the community as it has been facing a number of important changes and effects in the last few years, and they decide to focus on solving the problems looking at the development of eco-tourism as one of the ways they have to adapt to the effects of climate change, showing the resilience and adaptive capacity of the community.

In the narratives it can be observed that currently, tourists that go to the Cochamó valley only come to the community to take pictures and leave few benefits, and leaving waste and pollution behind. They need to develop a better touristic offer that can be based on the local culture, but they need support from the government to help them develop this area. They mention that they don't provide good services to the tourists and they need to develop new "attractions" that are based in their culture and traditional activities. They mention that currently there is no good information about what the community has to offer and that they don't have the support of the regional authorities. They need to know how to apply to public funds available to development of tourstic activities and how to involve to all the community in these activities.

The network of relationships between what stakeholders consider the most important scenarios to happen for the development of sustainable tourism development in the community of Cochamó is presented in Figure 4. They consider that to obtain a scenario with development of sustainable tourism, they need high hotel capacity, high advertising of Cochamó as a touristic destination and an attractive offer of related services. According to them, to obtain high hotel capacity, they need to have funds for the promotion of tourism in the region available, that such funds be easy to access for them and that they can develop high entrepreneurship capacity. To have high advertising of Cochamó as a touristic destination, the estimate that they need to have information about their services, an attractive web page for tourists and high quality touristic services. Finally, to have an attractive offer of touristic services, they need the support of local and regional authorities, capacity building in touristic services and a highly organized community.

When they assess their beliefs of existence of these scenarios (based on what they currently see), the conclude there is low probability (41.1%) of the occurrence of the desired scenario (sustainable tourism developed in Cochamó), explained mostly by low hotel capacity (51.9%), and the lack of an attractive touristic offer (51.1%). They consider that the probability of having high advertising of Cochamó as a touristic destination is 53.4%. Regarding the development of hotel capacity, they consider that it is highly probable that tourism promotion funds will be available (66%) and that they will have high entrepreneurship capacity (63%), but that the easy access to the funds is only 56% probable. Regarding the second first level

determinant, they consider that there is a 53.4% probability of having high advertising of Cochamó as a touristic destination, that information will exist with a 52% probability, that an attractive web page will exist with a 51% probability and that high quality touristic services will be developed with a 57% probability. Finally regarding the third scenario, they consider that an attractive touristic services offer will exist with a 48.9% probability, that they will have the support of authorities with a 48% probability, that they will have a highly organized community with a 49% probability and that the tourism capacity building will exist with a probability of 41%.

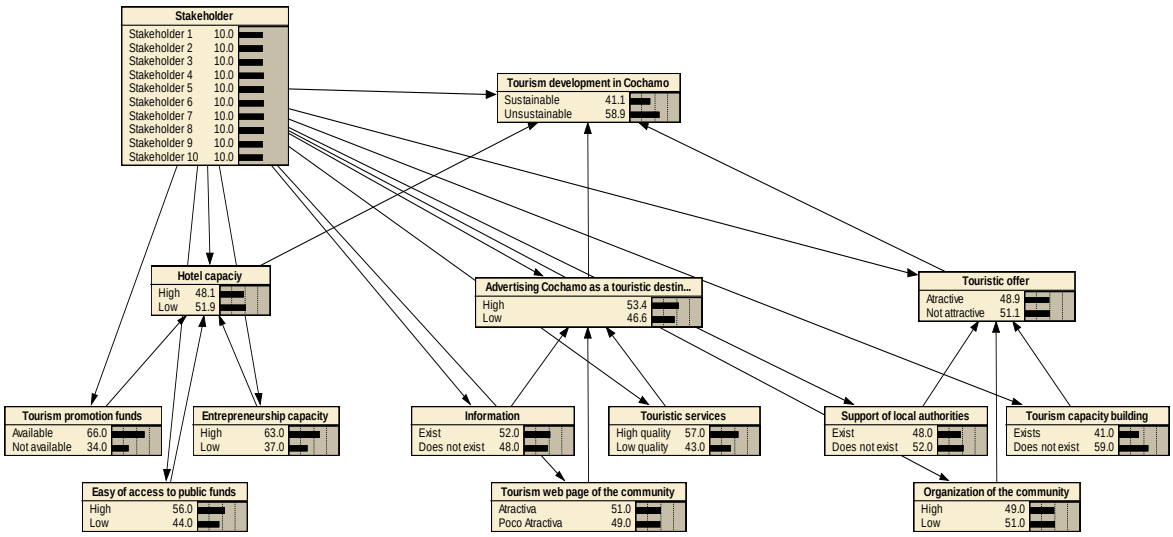

Figure 4: BBN tree from Second Workshop in Cochamó (Community Workshop)

Finally, the sensitivity analysis is presented in Table 2. We observe that stakeholder beliefs variation are a 7.48% of the total variation, Among the most important sources of variability in beliefs (what will affect the result the most) are hotel capacity (3.57% of variation), the existence of tourism promotion funds (1.5%), the existence of services for tourists (1.39%) and setting Cochamó as a touristic destination (1.25%).

Table 2: Sensitivity analysis of stakeholders beliefs in Second Workshop in Cochamó

Node	Mutual Information	Percent	Variance of Beliefts
Tourism development in Cochamó	0.9772	100.00	0.2421
Stakeholders	0.0731	7.48	0.0237
Hotel capacity	0.0349	3.57	0.0116

Tourism promotion funds	0.0147	1.50	0.0049
Offer of touristic services	0.0136	1.39	0.0046
Advertising			
Cochamo as a touristic destination	0.0122	1.25	0.0041
Easy access to public funds	0.0081	0.83	0.0027
Information	0.0061	0.62	0.0020
Support of tourism by local authorities	0.0059	0.61	0.0020
Tourism capacity building	0.0058	0.59	0.0019
Organization (cohesion) of the community	0.0026	0.27	0.0009
Entrepreneurship capacity	0.0021	0.21	0.0007
Web page of touristic servics	0.0018	0.18	0.0006
Touristic services	0.0010	0.10	0.0003

3.3 MANAGERS

The workshop for administrative and managerial personnel responsible for Cochamó and its region was held in Valparaíso. Ten people representing different government agencies attended the workshop and seven of them stayed the three hours until the BBN was completed. The agencies that were present were the Undersecretary of Fishing and Aquaculture (SUBPESCA), the National Service for Fishing (SERNAPESCA, in charge of fisheries and aquaculture enforcement), the Ministry of the Environment (MMA, in charge of the National Strategy and Action Plan for Climate Change). There were also present a number of consultants that worked for these agencies in Climate Change related projects.

The manager's workshop was a wide-ranging one, although it did retain a focus on the impacts of the selected drivers on local and regional marine resources. The following drivers served as the vantage point for the workshop: water quality, sea temperature, ocean acidification, pollution, and rain and the melting of glaciers. Managers believe that many of the drivers would

have an impact on fisheries resources and the occurrence of algae blooms. They believe that ocean acidification will have an impact on shells and carapaces which will in turn impact the rate of growth, the mortality of larvae and the mortality of important species and accordingly, the sustainability of both aquaculture and fishing. The discussion revealed concern for impacts of climate-change related and other stressors on the local and regional ecosystem, including changes in the habitat (less macro algae), reduction in biomass (and lower catch rates), changes in the resource base (migration of resources, presence of alien and invasive species) and impacts on specific species of local and regional interest (jibia, mussel seeds, lapa, locos and caracoles). The managers also discussed uncertainties relating to the modelling of climate change and its impacts. While impacts of and on other human activities were also discussed (thermoelectric plants, general economic impact, impact of sanation regulations, for example), most of the discussion focused on the natural system.

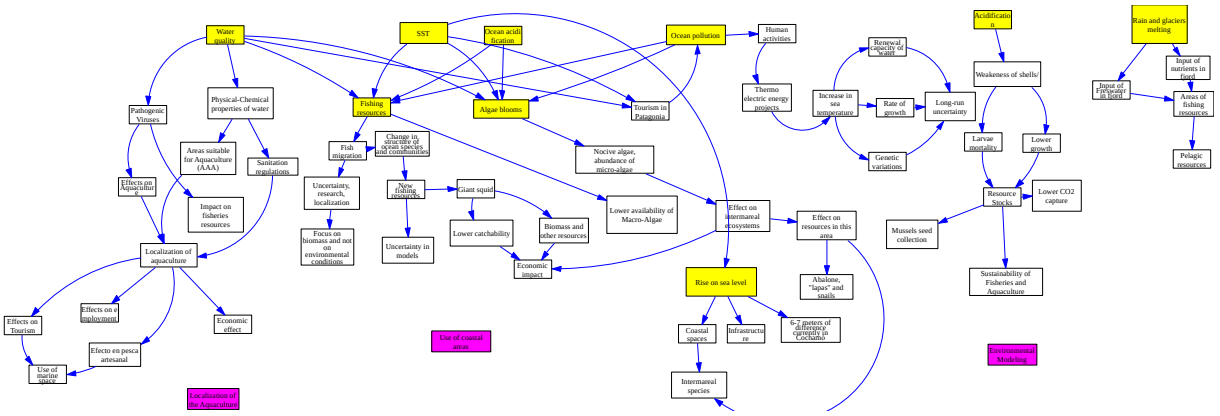

Figure 5: System Thinking Map for Third Workshop (Managers)

In the BBN session, however, managers selected as their most important issue the vulnerability of local communities to climate change. They then selected as key determinants of the vulnerability of coastal communities three factors, here represented as first level nodes: Sustainability, multisciplinary research and high/good governance. In doing so, they turned the focus of discussion to the factors that would in their estimation impact the adaptive capacity of the local community. They then selected three factors that they felt had a major impact on the three first level factors. Sustainability would be most impacted by 1) degree of resilience of local community, 2) productive activitiy in harmony with carrying capacity, and 3) whether the carrying capacity of the local ecosystem was known or not. The carrying out of interdisciplinary research would be most impacted by: 1) whether it receives sufficient funding; 2) whether there is an integrated focus to the research, and 3) whether there is sufficient capacity to carry out such

work. The quality of governance they thought depended upon: 1) the existence of an adequate legal framework; 2) the constructive participation of users (stakeholders) and 3) the existence of coordination among institutions.

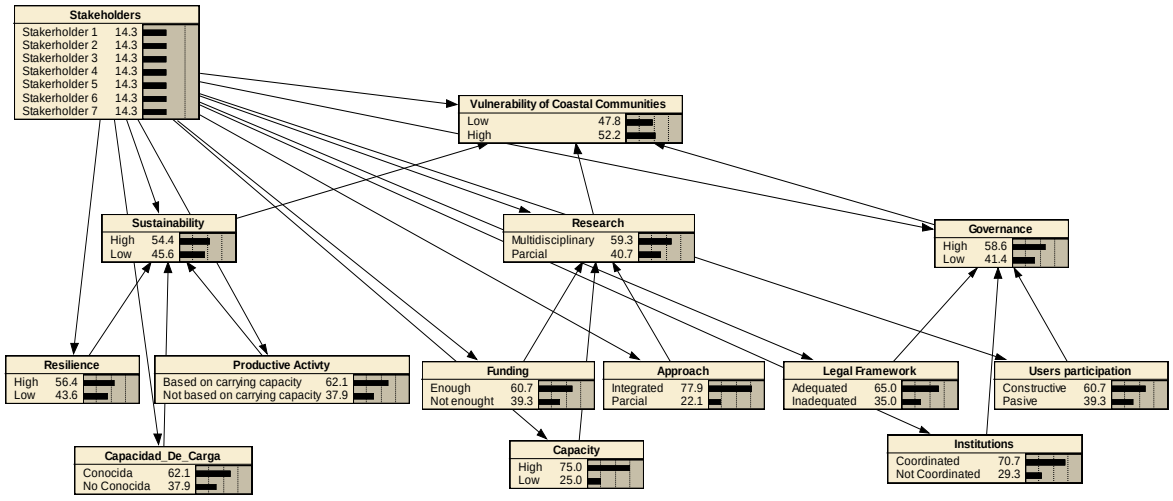

Figure 6: BBN Tree for Third Workshop (Managers)

A sensitivity analysis was performed on the conditional probability tables filled out by the managers. This is presented in Table 3. We observe that beliefs with respect to "sustainability" account for 14% of total variation among beliefs. The most important source of variability in beliefs is the involvement of stakeholders. There is a substantial jump to the cluster of variables that are thought to be next most important: governance (3.83 % of the variation) and research (3.2%). The productivity of the aquaculture activity and funding (of research) come next, accounting for about 2.5% of the variance each.

Table 3: Sensitivity Analysis for Manager's Workshop

Node	Mutual Info	Percent	Variance of Beliefs
Vulnerability of Coastal Communities	0.99857	100	0.2495057
Sustainabilit	0.14363	14.4	0.0478
Stakeholders	0.08968	8.98	0.0299952

Governance	0.03825	3.83	0.0130632
Research	0.03193	3.2	0.0109244
Production activity	0.02656	2.66	0.0090871
Funding	0.02508	2.51	0.0085911
Resilience	0.01617	1.62	0.0055655
Legal framework	0.01321	1.32	0.004539
Carrying capacity	0.00884	0.885	0.003045
Users participation	0.0065	0.651	0.0022406
Capacity	0.00441	0.442	0.0015181
Approach	0.00356	0.357	0.0012256
Institutions	0.00224	0.224	0.0007725

REFERENCES

Kjaerulff, U. B. and A. L. Madsen (2008). Bayesian Networks and Influence Diagrams: A Guide to Construction and Analysis. New York, Springer.

Richards, R., M. Sanó, et al. (2013). "Bayesian belief modeling of climate change impacts for informing regional adaptation options." Environmental Modelling & Software **44**(0): 113-121.

Sterman, J. (2000). Business Dynamics, {McGraw Hill Higher Education}.

Tiller, R., R. Gentry, et al. (2013). "Stakeholder driven future scenarios as an element of interdisciplinary management tools; the case of future offshore aquaculture development and the potential effects on fishermen in Santa Barbara, California." Ocean & Coastal Management **73**(0): 127-135.

Tiller, R. G., J. Mork, et al. (2015). "To Adapt or Not Adapt: Assessing the Adaptive Capacity of Artisanal Fishers in the Trondheimsfjord (Norway) to Jellyfish (Periphylla periphylla) Bloom and Purse Seiners." Marine and Coastal Fisheries **7**(1): 260-273.